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ABSTRACT

This packet contains learning modules for a self-paced course in aircraft environmental systems mechanics that was developed for the Air Force. Each learning module consists of some or all of the following: objectives, instructions, equipment, procedures, information sheets, handouts, self-tests with answers, review section, tests, and response sheets. Topics covered in the learning modules are the following: maintenance tools, glossary, mathematics, aircraft familiarization, safety, physics, electron theory, magnetism, circuits, wiring diagrams, control and protective devices, test equipment, Kirchhoff's current law, series circuit troubleshooting, parallel circuit troubleshooting, Kirchhoff's voltage law, use of general purpose connectors, bonding, shielding, grounding, wiring maintenance, electrical hardware, aircraft air conditioning system moisture separator, maintenance of bleed air distribution ducting, cleaning agents and lubricants, controlling corrosion, air turbine motors, turbine refrigeration devices, windshield clearing system, air control valves, bench check air control units, controls of MB-3 leakage tester, airflow control and shutoff valve, bench check airflow regulator, anti-gravity system, anti-gravity suit valve, canopy seal system, pressurization principles, pressurization systems, oxygen systems, and refrigeration systems. A plan of instruction is included in the packet. (KC)

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ED265357

AIRCRAFT ENVIRONMENTAL SYSTEMS MECHANIC

PART 1

Chanute Technical Training Center
Chanute Air Force Base, Illinois

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POI C3ABR42331 000
(PDS Code ANZ)

PLAN OF INSTRUCTION
(Technical Training)

AIRCRAFT ENVIRONMENTAL SYSTEMS MECHANIC

CHANUTE TECHNICAL TRAINING CENTER

6 July 1983-Effective 6 July 1983 with class 830706

LIST OF CURRENT PAGES

This POI consists of 123 current pages listed as follows:

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DEPARTMENT OF THE AIR FORCE
3330 Technical Training Wing (ATC)
Chanute Air Force Base, Illinois 61868

PLAN OF INSTRUCTION C3ABR42331 000
(PDS Code ANZ)
6 July 1983

FOREWORD

1. PURPOSE: This publication is the plan of instruction (POI) when the pages listed on page A are bound into a single volume. The POI contains the qualitative requirements for course C3ABR42331 000, Aircraft Environmental Systems Mechanic, in terms of criterion objectives for each unit of instruction and shows time, training standard correlation, and support materials and guidance. When separated into units of instruction, it becomes the lesson plan/Part I. This POI was developed according to AFR 50-8, Instructional System Development, and ATCR 52-6, Curriculum Documentation.

2. COURSE DESIGN/DESCRIPTION: The instructional design for this course is self-paced and/or small group paced. Class is conducted on a restructured 8-hour training day. This plan allows for discontinuance of routine trainer work and operation of the test room stations during the last two hours of the day for Blocks I, II, and III. Students are allowed to continue self-instruction projects in the study stations during this period. Supervisors are given the latitude to make daily assessments and to open lab stations and test room stations on an as needed basis to preclude student backups. Supervisors are permitted to vary lesson sequence within a block as necessary to insure students have self-study materials to study during the afternoon period. The course trains personnel to perform duties prescribed in AFR 39-1 for Aircraft Environmental Systems Mechanic, AFSC 42331. It includes organizational and field maintenance of aircraft pressurization, air conditioning (heating, cooling, humidity control, etc.), engine bleed air, oxygen, anti-icing, defogging, fire extinguishing, air turbine, cryotainer systems maintenance, liquid refrigeration systems, and life raft inflation equipment. In addition, military training is provided for commander's calls and physical conditioning. Multiple instructor requirements are based on Course Manpower Standard Data Sheets dated 10 December 1980. Objectives preceded by an asterisk (*) involve safety and must meet the multiple instructor requirements.

3. TRAINING EQUIPMENT: The number shown in parentheses after equipment listed as Training Equipment under SUPPORT MATERIALS AND GUIDANCE is the planned number of students assigned to each equipment unit.

4. REFERENCES: This POI is based on Specialty Training Standard 423X1, February 1983, and Course Chart C3ABR42331 000, 2 May 1983.

FOR THE COMMANDER

GERALD B. LASCO, Colonel, USAF
Commander
3370 Technical Training Group

Supersedes POI C3ABR42331 000, 24 November 1982.
OPR: 3370 Technical Training Group
DISTRIBUTION: Listed on Page A

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
1. Orientation	6.5
a. School orientation conducted IAW CR 50-18, Attachment 3 outline. STS: None Meas: None	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-SG-101, Orientation
C3ABR42331-HO-101, Glossary of Terms
C3ABR42331-HO-101A, Coefficient Handout
C3ABR42331-HO-101B, Rules, Laws and Formulas
C3ABR42331-HO-101C, Orientation Handout
ATC PT 52-11, Study Skills

Audio Visual Aids
NSC 42-11, Slides and Cassette Orientation

Training Methods
Discussion (3.5 hrs)
Self-Instruction (3 hrs)

Instructional Guidance
The instructor will supervise the class period, issue the correct course materials, present an audio visual presentation, and elaborate vocally on various items of the orientation to insure that the students understand school policies, procedures, and course materials. The instructor will refer to Part II, Teaching Guide, for detailed instruction on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
2. Security	2

a. Specify basic facts relating to the classification of information. A minimum of three out of three must be correct. STS: 2a(1) Meas: PC

b. Specify basic facts relating to the use of essential elements of friendly information. A minimum of two out of two must be correct. STS: 2a(1) Meas: PC

c. Specify basic facts relating to the prevention of nontechnical COMSEC violations. A minimum of three out of three must be correct. STS: 2a(2) Meas: PC

d. Identify OPSEC vulnerabilities in AFSC 423X1. A minimum of two out of two must be correct. STS: 2b(6) Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-102, Security
C3ABR42331-PT-102A, Operations Security Program (OPSEC)
C3ABR42331-WB-102, Security

Audio Visual Aids
NSC 34-2, Slide and Cassette (COMSEC Module 1)

Training Methods
Discussion (1 hr)
Self-Instruction (1 hr)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct course materials. Counsel student as needed regarding academic and nonacademic reasons and supervise clean-up periods. The instructor will provide individual assistance to each student as needed during class. The instructor will refer to Part II teaching guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
3. Progression and Duties of Aircraft Environmental Systems Specialists	2

a. Identify basic facts relating to career ladder progression for aircraft environmental systems specialists. A minimum of four out of five must be correct. STS: 1a Meas: PC

b. Relate career field duties to AFSCs 42331, 42351, 42371. A minimum of four out of five must be correct. STS: 1b Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-103, Progression In and Duties of the Aircraft Environmental Systems Specialist

Training Methods
Self-Instruction (2 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
4. Safety	3

4. Safety

a. Identify hazards of the environmental systems career field. A minimum of one out of one must be correct. STS: 3a Meas: PC

b. Identify AFOSH standards for the environmental systems career field. A minimum of one out of one must be correct. STS: 3b Meas: PC

c. Specify safe work procedures consistent with the work area. A minimum of two out of two must be correct. STS: 3c Meas: PC

d. Specify the protective measures to take while working around high intensity sound. A minimum of one out of one must be correct. STS: 3d Meas: PC

e. Specify general housekeeping procedures which are consistent with safety. A minimum of one out of one must be correct. STS: 3e(1) Meas: PC

f. Specify general housekeeping procedures which are consistent with fire prevention. A minimum of two out of two must be correct. STS: 3e(2) Meas: PC

g. Identify markings applicable to radioactive parts and materials. A minimum of one out of one must be correct. STS: 3f Meas: PC

h. Identify precautions to be taken while working near radiation. A minimum of one out of one must be correct. STS: 3g Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-104, Safety

Training Methods
Self-Instruction (3 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic
BLOCK TITLE Fundamentals	

1. COURSE CONTENT	2. TIME
5. Aircraft Familiarization	3
a. Relate basic facts to elements of the aircraft designation system. A minimum of four out of five must be correct. STS: 9a Meas: PC	
b. Relate basic facts to the aircraft station numbering system reference lines. A minimum of four out of five must be correct. STS: 9b Meas: PC	
c. State general principles relating to major aircraft systems. A minimum of three out of four must be correct. STS: 9c Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-105, Aircraft Familiarization

Training Methods
Self-Instruction (3 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE

Fundamentals

1. COURSE CONTENT	2. TIME
6. Elements of Physics	1.5

a. State general principles relating to the effect of temperature on gases. A minimum of two out of two must be correct. STS: 11b(2) Meas: PC

b. State general principles relating to the effect of pressure on gases. A minimum of two out of two must be correct. STS: 11c Meas: PC

c. State general principles relating to the effect of atmospheric conditions on pressure. A minimum of three out of three must be correct. STS: 11d(1) Meas: PC

d. State general principles relating to the effect of atmospheric conditions on temperature. A minimum of three out of three must be correct. STS: 11d(2) Meas: PC

e. State general principles relating to the effect of atmospheric conditions on humidity. A minimum of three out of three must be correct. STS: 11d(3) Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-106, Physics of Solids, Liquids and Gases

Training Methods
Self-Instruction (1.5 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to the Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
7. Electron Theory	4.5

a. State general facts relating to electricity, A minimum of 12 out of 15 must be correct. STS: 12 Meas: PC

b. State general principles relating to electrical conductors. A minimum of four out of five must be correct. STS: 11a(1) Meas: PC

c. State general principles relating to electrical insulators. A minimum of one out of one must be correct. STS: 11a(2) Meas: PC

d. State general principles relating to the effects of temperature on metals. A minimum of one out of one must be correct. STS: 11b(1) Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-107, Electron Theory

Training Methods
Self-Instruction (4.5 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to the Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
8. Magnetism	2.5

a. State basic facts relating to magnetism. A minimum of eight out of ten must be correct. STS: 12 Meas: PC

b. Given four groups of electromagnetic coils, use the left-hand rule to determine the correct polarity for a minimum of three out of four groups. STS: 12 Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-108, Magnetism

Training Methods
Self-Instruction (2.5 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to the Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
9. DC Generation and Basic Circuit Symbols and Terms	3
a. Specify basic facts relating to the generation of DC voltage. A minimum of four out of five must be correct. STS: 12 Meas: PC	
b. Identify basic electrical circuit symbols. A minimum of four out of five must be correct. STS: 13c, 13d Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

C3ABR42331-PT-109, DC Generation and Basic Circuit Symbols and Terms

Training Methods

Self-Instruction (3 hrs)

Instructional Guidance

The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to the Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic
BLOCK TITLE Fundamentals	

1. COURSE CONTENT	2. TIME
10. Wiring Diagrams	3.5

a. Identify basic wiring diagram symbols. A minimum of four out of five must be correct. STS: 13c, 13d Meas: PC

b. Specify basic facts relating to wire identification codes. A minimum of four out of five must be correct. STS: 13c, 13d Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-110, Wiring Diagrams Fundamentals

Training Equipment
Trainer P/N 18 71 4112, Electrical Components (1)
Trainer P/N 18 71 4113, Bridge Circuit Components (1)
Trainer P/N 18 71 4114, Electrical Components (1)

Training Methods
Self-Instruction (3.5 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to the Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
11. Control and Protective Devices	2
a. Specify basic facts about circuit protective devices. A minimum of four out of five must be correct. STS: 12 Meas: PC	
b. Specify basic facts about circuit control devices. A minimum of eight out of ten must be correct. STS: 12 Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-111, Control and Protective Devices

Training Equipment
Trainer P/N 18 71 4112, Electrical Components (1)
Trainer P/N 18 71 4113, Bridge Circuit Components (1)
Trainer P/N 18 71 4114, Electrical Components (1)

Training Methods
Self-Instruction (2 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to the Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
12. Multimeter	12.5
a. Given a power bench, a voltage, current, and resistance readings test board, and a PSM-37 multimeter, measure to the nearest graduation on the meter's scale four sets of electrical values. A minimum of nine out of ten of the DC voltage, AC voltage, and DC current sets must be correct. A minimum of four out of five of the resistance sets must be correct. STS: 14a(1) Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-112, Use of Test Equipment (PSM-37 Multimeter)

Training Equipment
Multimeter (PSM-37) (1)
Trainer P/N 18 73 4344, Voltage Current and Resistance Readings (1)
Trainer P/N 18 72 4320, Trainer Workbench Power Supply

Training Methods
Self-Instruction (5.5 hrs)
Performance (7 hrs)

Instructional Guidance
The classroom and/or lab instructor will supervise the class study and/or lab period, administer, evaluate, and critique progress checks, and performance exercises, insure student has correct module material and equipment, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class/lab periods. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

13. Written Test and Critique	1.5

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
14. Kirchhoff's Current Law	1.5
a. Apply Kirchhoff's current law to solve for unknown electrical values in basic electrical circuits. A minimum of four out of five must be correct. STS: 12 Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-114, Kirchhoff's Current Law

Training Methods
Self-Instruction (1.5 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, supervise cleanup periods, and provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
15. Kirchhoff's Voltage Law	1.5
a. Use Kirchhoff's voltage law to solve for unknown values in basic electrical circuits. A minimum of eight out of ten unknown values must be correct. STS: 12, 13c Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-115, Kirchhoff's Voltage Law

Training Methods
Self-Instruction (1.5 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibiliteis Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
16. Ohm's Law	1.5
a. Use Ohm's law formulas to solve for unknown electrical values. A minimum of four out of five must be correct. STS: 12 Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-116, Ohm's Law

Training Methods
Self-Instruction (1.5 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
17. Series Circuits a. Use applicable laws and formulas to solve for unknown electrical values in series circuits. A minimum of four out of five must be correct. STS: 12 Meas: PC b. Given indicated circuit discrepancies and meter readings, specify malfunctions on series circuits. A minimum of four out of five must be correct. STS: 13e(1) Meas: PC	4.5

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-117, Series Circuit
C3ABR42331-PT-117A, Series Circuit

Training Equipment
Multimeter (PSM-37) (1)
Trainer P/N 18 73 4347, Series Circuits (1)
Trainer P/N 18 72 4320, Trainer Workbench Power Supply (2)

Training Methods
Self-Instruction (2.5 hrs)
Performance (2 hrs)

Instructional Guidance
The classroom and/or lab instructor will supervise the study class study and/or lab period, administer, evaluate, and critique progress checks and performance exercises, insure student has correct module materials and equipment, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan. When a group of students, five or more, are experiencing unneeded difficulty with this material and the instructor/supervisor feels that individual assistance would cause a backlogging of students, group pace will be used.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
18. Parallel Circuits	4.5

a. Use applicable laws and formulas to solve for unknown electrical values in parallel circuits. A minimum of four out of five must be correct. STS: 12 Meas: PC

b. Given indicated circuit discrepancies and meter readings, specify malfunctions on parallel circuits. A minimum of four out of five must be correct. STS: 13e(1) Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

C3ABR42331-PT-118, Parallel Circuits
C3ABR42331-PT-118A, Parallel Circuits

Training Equipment

Multimeter (PSM-37) (1)
Trainer P/N 18 73 4350, Parallel Circuits (1)
Trainer P/N 18 72 4320, Trainer Work Bench Power Supply (2)

Training Methods

Self-Instruction (2.5 hrs)
Performance (2 hrs)

Instructional Guidance

The classroom and/or lab instructor will supervise the student class study and/or lab period, administer, evaluate, and critique progress checks and performance exercises, insure student has correct module materials and equipment, counsel student as needed regarding academic and nonacademic reasons and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan. When a group of students, five or more, are experiencing unneeded difficulty with this material and the instructor supervisor feels that individual assistance would cause a backlogging of students, group pace will be used.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic
BLOCK TITLE Fundamentals	

1. COURSE CONTENT	2. TIME
19. Series-Parallel Circuits	15

a. Use applicable laws and formulas to solve for unknown electrical values in series-parallel circuits. A minimum of four out of five must be correct. STS: 12 Meas: PC

b. Given indicated circuit discrepancies and meter readings, specify malfunctions on series-parallel circuits. A minimum of three out of four must be correct. STS: 13e(1) Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-119, Series-Parallel Circuits
C3ABR42331-PT-119A, Series-Parallel Circuits

Training Equipment
Multimeter (PSM-37)
Trainer P/N 18 73 4346, Series Parallel Circuits (1)
Trainer P/N 18 72 4320, Trainer Work Bench Power Supply (2)

Training Methods
Self-Instruction (10 hrs)
Performance (5 hrs)

Instructional Guidance
The classroom instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan. When a group of students, five or more, are experiencing unneeded difficulty with this material and the instructor supervisor feels that individual assistance would cause a backlogging of students, group pace will be used.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic
BLOCK TITLE Fundamentals	

1. COURSE CONTENT	2. TIME
20. Switching Circuits a. Specify basic facts relating to relay switching circuit devices. A minimum of three out of three must be correct. STS: 12 Meas: PC	3

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-120, Introduction to Relays

Training Methods
Self-Instruction (3 hrs)

Instructional Guidance
The classroom instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
21. DC Motors and Control Circuits	8.5

21. DC Motors and Control Circuits

a. Specify basic facts relating to DC motors. A minimum of seven out of nine must be correct. STS: 12 Meas: PC

b. Given a DC motor control circuit wiring diagram with indicated malfunctions and circuit discrepancies, specify which malfunction caused each discrepancy. A minimum of four out of five must be correct. STS: 13c, 13d, 13e(1) Meas: PC

c. Using housekeeping practices consistent with safety and fire prevention and given a DC motor control circuit trainer, wiring diagram, and a multimeter, troubleshoot circuit problems. A minimum of four out of five must be correct. STS: 3e(1), 3e(2), 13c, 13d, 13e(1), 16c Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-121, DC Motors
C3ABR42331-WB-121, DC Motors and Control Circuits Wiring Diagram
C3ABR42331-WB-121A, DC Motors and Control Circuits Troubleshooting

Training Equipment
Multimeter (PSM-37) (1)
Trainer P/N 18 50 1387, DC Reversible Motor System (1)
Trainer P/N 18 50 1318, Actuator Valve Assembly Display (1)

Training Methods
Self-Instruction (1.5 hrs)
Performance (7 hrs)

Instructional Guidance
The classroom and/or lab instructor will supervise the student class study and/or lab period, administer, evaluate, and critique progress checks and performance exercises, insure student has correct module materials and equipment, counsel student as needed regarding academic and nonacademic reasons and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class/lab periods. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic
BLOCK TITLE Fundamentals	

1. COURSE CONTENT	2. TIME
22. Temperature Control Circuits	10
a. State general principles relating to basic temperature control circuits. A minimum of four out of five must be correct. STS: 12, 13a(1) Meas: PC	(3)
b. Given a basic temperature control circuit wiring diagram with indicated malfunctions and temperature control circuit discrepancies, specify which malfunction caused each discrepancy. A minimum of six out of eight must be correct. STS: 13c, 13d, 13e(1) Meas: PC	(4)
c. Given a temperature control circuit trainer, diagram, and a multimeter, troubleshoot circuit problems. A minimum of four out of five must be correct. STS: 13c, 13d, 13e(1), 16c Meas: PC	(3)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-122, Temperature Controlling Bridge Circuits
C3ABR42331-WB-122, Temperature Control Circuits Wiring Diagram
C3ABR42331-WB-122A, Temperature Control Circuits Troubleshooting

Training Equipment
Multimeter (PSM-37) (1)
Trainer P/N 18 63 3072, Bridge Circuit (1)

Training Methods
Self-Instruction (3 hrs)
Performance (7 hrs)

Instructional Guidance
The classroom and/or lab instructor will supervise the student class study and/or lab period, administer, evaluate, and critique progress checks, performance exercises, insure student has correct module materials and equipment, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class/lab periods. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic
BLOCK TITLE Fundamentals	

1. COURSE CONTENT	2. TIME
23. Alternating Current	1
a. Specify basic facts relating to alternating current. A minimum of five out of six must be correct. STS: 12 Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-123, Alternating Current

Training Methods
Self-Instruction (1 hr)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
24. Capacitance	.5
a. Specify basic facts relating to capacitance. A minimum of eight out of ten must be correct. STS: 12 Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-124, Capacitance

Training Methods
Self-Instruction (.5 hr)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
25. Inductance	.5
a. Specify basic facts relating to inductance. A minimum of eight out of ten must be correct. STS: 12 Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-125, Inductance

Training Methods
Self-Instruction (.5 hr)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class. The instructor will refer to Part II Teaching Guide for detailed instruction on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
26. AC Motors and Control Circuits	10
a. Specify basic facts relating to AC motors. A minimum of four out of five must be correct. STS: 12 Meas: PC	(1)
b. Given an AC motor control circuit wiring diagram with indicated malfunctions and circuit discrepancies, specify which malfunction caused each discrepancy. A minimum of five out of six must be correct. STS: 13c, 13d, 13e(1) Meas: PC	(3.5)
c. Given an AC motor control circuit trainer, wiring diagram, and a multimeter, troubleshoot circuit problems. A minimum of four out of five must be correct. STS: 13c, 13d, 13e(1), 16c Meas: PC	(5.5)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-126, AC Motors
C3ABR42331-WB-126, AC Motors and Control Circuits Wiring Diagram
C3ABR42331-WB-126A, AC Motors and Control Circuits Troubleshooting

Training Equipment
Multimeter (PSM-37) (1)
Trainer P/N 18 63 2999, Valve Control System (1)
Trainer P/N 18 50 1318, Actuator Valve Assembly Display (1)

Training Methods
Self-Instruction (1 hr)
Performance (9 hrs)

Instructional Guidance
The classroom and/or lab instructor will supervise the class and/or lab period, administer, evaluate, and critique progress checks and performance exercises, insure student has correct module materials and equipment, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class/lab periods. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
27. Solid State Devices	1.5
a. State general principles relating to solid state devices. A minimum of eight out of ten must be correct. STS: 12, 13a(4) Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-127, Principles of Solid State Devices

Training Methods
Self-Instruction (1.5 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module materials, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechani

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
28. Magnetic Amplifiers	4
a. State general principles about magnetic amplifier type temperature controllers. A minimum of four out of five must be correct. STS: 12, 13a(3) Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-128, Magnetic Amplifiers

Audio Visual Aids
Transparency, Magnetic Amplifier Circuits CT 73-1584 (1)

Training Methods
Self-Instruction (4 hrs)

Instructional Guidance
The instructor will supervise the class period, administer, evaluate, and critique progress checks, insure student has correct module material, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Fundamentals

1. COURSE CONTENT	2. TIME
29. Trainer Aircraft Air Conditioning System	12.5
a. State general principles relating to a trainer aircraft air conditioning system. A minimum of 16 out of 20 must be correct. STS: 16a(4) Meas: PC	(3.5)
b. Given a trainer aircraft air conditioning system wiring diagram with indicated malfunctions and system discrepancies, specify which malfunction caused each discrepancy. A minimum of five out of six must be correct. STS: 13c, 13d, 13e(1), 16d(1) Meas: PC	(3.5)
c. Given a trainer aircraft air conditioning system trainer, wiring diagram, and a multimeter, troubleshoot system problems. A minimum of four out of five must be correct. STS: 13c, 13d, 13e(1), 16c, 16d(1) Meas: PC	(5.5)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-129, Trainer Aircraft Air Conditioning
C3ABR42331-WB-129, Trainer Aircraft Air Conditioning System Wiring Diagram
C3ABR42331-WB-129A, Trainer Aircraft Air Conditioning System Troubleshooting

Training Equipment
Multimeter (PSM-37) (1)
Trainer P/N 18 66 3301, Trainer Aircraft Air Conditioning System (2)

Training Methods
Self-Instruction (3.5 hrs)
Performance (9 hrs)

Instructional Guidance
The classroom and/or lab instructor will supervise the student class study and/or lab period, administer, evaluate, and critique progress checks and performance exercises, insure student has correct module materials and equipment, counsel student as needed regarding academic and nonacademic reasons, and supervise cleanup periods. The instructor will provide individual assistance to each student as needed during class/lab periods. The instructor will refer to Part II Teaching Guide for detailed instructions on this module and to Instructor Responsibilities Sheet found at the front of this station lesson plan.

30. Military Training 7

    a. Physical Conditioning (7)

31. Written Test and Critique 1.5

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Air Conditioning Systems

1. COURSE CONTENT	2. TIME
1. Decade Resistor Functions and Windshield Amplifier Bench Check	2.5
a. Associate four out of five switch controls or binding posts of the decade resistor to their function. STS: 14a(2) Meas: PC	(.5)
b. Given an illustration of the panel face of the decade resistor with predetermined control settings, compute a minimum of three out of four decade switch control settings for designated switches into total ohms resistance. STS: 14a(2) Meas: PC	(1.5)
c. Given a decade resistor and predetermined decade's total ohms resistance, program a minimum of three out of four decade switch control settings properly under the proper decade switch designations. STS: 14a(2) Meas: PC	(.5)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-201, Decade Resistors
C3ABR42331-WB-201, Decade Resistors
C3ABR42331-WB-201A, Decade Resistors

Training Equipment
Decade Box (1)

Training Methods
Self-Instruction (2 hrs)
Performance (.5 hrs)

Instructional Guidance
The instructor will issue programmed text, workbook, and training equipment to each student. Each student must satisfactorily accomplish each objective before he/she can proceed to the next unit of instruction. After satisfactory completion of PT-201, direct the student to complete WB-201, and then WB-201A. The instructor will ensure that all training equipment used by the student is turned in and properly stored. Where feasible, shut off operating equipment to conserve energy. Ensure student complies with safety practices IAW applicable AFOSH standards.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic

BLOCK TITLE
Air Conditioning Systems

1. COURSE CONTENT	2. TIME
2. Fighter Cabin Air Conditioning Systems	24
a. Relate a minimum of eight out of ten bleed air system components to their operation. STS: 15a Meas: PC	(4)
b. Relate a minimum of eight out of ten fighter cabin air conditioning system components to their operation. STS: 16a(1) Meas: PC	(4.5)
c. Relate a minimum of four out of five defog system components to their operation. STS: 17a(3) Meas: PC	(.5)
d. Using a wiring diagram for the air conditioning system, specify causes for system troubles with a minimum score of 48 out of 60 total points. STS: 16d(1) Meas: PC	(5)
e. Using a multimeter and wiring diagram, troubleshoot the cabin air conditioning system trainer, locating three out of four troubles correctly. STS: 16d(1) Meas: PC	(10)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-202, Fighter Bleed Air System
C3ABR42331-PT-202A, Fighter Cabin Air Conditioning System
C3ABR42331-WB-202, Fighter Cabin Air Conditioning System
C3ABR42331-WB-202A, Fighter Cabin Air Conditioning System Troubleshooting

Training Equipment
Trainer 3305, Fighter Air Conditioning (1)

Training Methods
Self-Instruction (9 hrs)
Performance (15 hrs)

Instructional Guidance
The instructor will issue programmed text, workbook, and training equipment to each student. Each student must satisfactorily accomplish each objective before he/she can proceed to the next unit of instruction. After satisfactory completion of PT-202A, direct the student to complete WB-202, Fighter Cabin Air Conditioning System Wiring Diagram. The instructor will ensure that all training equipment used by the student is turned in and properly stored. Where feasible, shut off operating equipment to conserve energy. Ensure student complies with safety practices IAW applicable AFOSH standards.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Air Conditioning Systems

1. COURSE CONTENT	2. TIME
3. Rain Removal Systems	13
a. Relate eight out of ten components of the rain removal system to their operation. STS: 17a(4) Meas: PC	(2)
b. Using an electrical diagram, identify and record the cause for given discrepancies achieving a minimum of 32 out of 40 total points. STS: 17d Meas: PC	(4)
c. Using a multimeter and wiring diagram, troubleshoot the rain removal system trainer, locating three out of four troubles correctly. STS: 17d Meas: PC	(4.5)
d. Given the functional test procedures for the windshield temperature control circuitry, the power bench with unit-B, and related test equipment, perform a functional test and record the correct procedures number and the remedy for abnormal indications for two given problems. STS: 17g Meas: PC	(2.5)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-203, Rain Removal System
C3ABR42331-WB-203, Rain Removal System Wiring Diagram
C3ABR42331-WB-203A, Rain Removal System Troubleshooting
C3ABR42331-WB-203B, Windshield Temperature Control Circuit Functional Test Procedures

Training Equipment
Trainer, 3336, Rain Removal System (1)
Multimeter (1)
Decade Resistor (1)
Power Bench with Unit-B (1)

Training Methods
Self-Instruction (2 hrs)
Performance (11 hrs)

Instructional Guidance
The instructor will issue programmed text, workbooks, and training equipment to each student. Each student must satisafctorily accomplish each objective before he/she can proceed to the next unit of instruction. After satisfactory completion of the objectives, the instructor will insure that all training equipment used by the student is turned in and properly stored. Where feasible, shut off operation equipment to conserve energy. Ensure student complies with safety practices IAW applicable AFOSH standards.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Air Conditioning Systems

1. COURSE CONTENT	2. TIME
4. Equipment Air Conditioning System	16
a. Associate eight out of ten fighter air conditioning system components to their operation. STS: 16a(1) Meas: PC	(4)
b. Using a wiring diagram, specify causes for equipment air conditioning system troubles with a minimum score of 80 out of 100 total points. STS: 16d(2) Meas: PC	(6)
c. Using a multimeter and wiring diagram, troubleshoot the equipment air conditioning system trainer, locating three out of four troubles correctly. STS: 16d(2) Meas: PC	(6)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-204, Equipment Air Conditioning System
C3ABR42331-WB-204, Equipment Air Conditioning System Wiring Diagram
C3ABR42331-WB-204A, Equipment Air Conditioning System Troubleshooting

Training Equipment
Trainer 3305, Fighter Air Conditioning (1)
Multimeter (1)

Training Methods
Self-Instruction (4 hrs)
Performance (12 hrs)

Instructional Guidance
The instructor will issue programmed text, workbook, and training equipment to each student. Each student must satisfactorily accomplish each objective before he/she can proceed to the next unit of instruction. After satisfactory completion of PT-204, direct the student to complete C3ABR42331-WB-204, Equipment Air Conditioning System Wiring Diagram. The instructor will ensure that all training equipment used by the student is turned in and properly stored. Where feasible, shut off all operating equipment to conserve energy. Ensure student complies with safety practices IAW applicable AFOSH standards.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic

BLOCK TITLE
Air Conditioning Systems

1. COURSE CONTENT	2. TIME
5. Temperature Control System Tester	7
a. Associate four out of five controls on the illustration of the temperature control system tester (AN/PSM-21) with their function. STS: 14b Meas: PC	(2.5)
b. Using a temperature control system tester and multimeter, troubleshoot the air conditioning systems trainer, correctly locating three out of four of the assigned troubles. STS: 14b Meas: PC	(4.5)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-205, Temperature Control System Tester
C3ABR42331-WB-205, Temperature Control System Tester

Training Equipment
Trainer 3305, Fighter Air Conditioning (1)
Multimeter (1)
Test Set, AN/PSM-21A (1)

Training Methods
Self-Instruction (2.5 hrs)
Performance (4.5 hrs)

Instructional Guidance
The instructor will ensure that all training equipment used by the student is turned in and properly stored. Where feasible, shut off operating equipment to conserve energy. Ensure student complies with safety practices IAW applicable AFOSH standards.

6. Written Test and Critique 1.5

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Air Conditioning Systems

1. COURSE CONTENT	2. TIME
7. Bomber Air Conditioning System	24
a. Relate eight out of ten bleed air system components to their operation. STS: 15a Meas: PC	(4)
b. Relate eight out of ten cabin air condtiioning system components to their operation. STS: 16a(2) Meas: PC	(4)
c. Using a wiring diagram, specify causes for air conditioning system troubles attaining a minimum of 48 out of 60 possible points. STS: 16d(1) Meas: PC	(8)
d. Using a multimeter and wiring diagram, troubleshoot the cabin air conditioning system trainer, locating a minimum of three out of four troubles correctly. STS: 16d(1) Meas: PC	(8)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-207, Bomber Bleed Air Supply System
C3ABR42331-PT-207A, Bomber Air Conditioning System
C3ABR42331-WB-207, Bomber Air Conditioning System Wiring Diagram
C3ABR42331-WB-207A, Bomber Air Conditioning System Troubleshooting

Training Equipment
Trainer 2518, Bomber Air Conditioning System (1)
Multimeter (1)

Training Methods
Self-Instruction (8 hrs)
Performance (16 hrs)

Instructional Guidance
The instructor will issue programmed text, workbook, and training equipment to each student. Each student must satisfactorily accomplish the objective before he/she can proceed to the next unit of instruction. After satisfactory completion of PT-207, direct the student to C3ABR42331-WB-207, Bomber Air Conditioning System Wiring Diagram. The instructor will ensure that all training equipment used by the student is turned in and properly stored. Where feasible shut off equipment to conserve energy. Ensure student complies with safety practices IAW applicable AFOSH standards.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic

BLOCK TITLE
Air Conditioning Systems

1. COURSE CONTENT	2. TIME
8. Cargo Bleed Air and Anti-Icing System	18
a. Relate a minimum of eight out of ten cargo bleed air system components to their operation. STS: 15a Meas: PC	(3)
b. Relate a minimum of eight out of ten cargo bleed air anti-icing system components to their operation. STS: 17a(5) Meas: PC	(6)
c. Using a wiring diagram, specify the causes for a minimum of four out of five anti-icing system circuit troubles. STS: 17d Meas: PC	(9)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-208, Cargo Aircraft Engine Bleed Air System
C3ABR42331-PT-208A, Wing and Empennage Anti-Icing System

Training Methods
Self-Instruction (9 hrs)
Performance (9 hrs)

Instructional Guidance
The instructor will issue programmed text and training equipment to each student. Each student must satisfactorily accomplish each objective before he/she can proceed to the next unit of instruction. The instructor will ensure that all training equipment used by the student is turned in and properly stored. When feasible, shut off operating equipment to conserve energy.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic
BLOCK TITLE Air Conditioning Systems	

1. COURSE CONTENT	2. TIME
9. Cargo Air Conditioning System	22
a. Relate eight out of ten cargo air conditioning system components to their operation. STS: 16a(3) Meas: PC	(2.5)
b. Relate eight out of ten mercury thermostat temperature control system components to their operation. STS: 13a(2) Meas: PC	(4.5)
c. Using a wiring diagram, specify the symptoms for ten cargo air conditioning system electrical troubles. A minimum of eight must be correct. STS: 16d(1) Meas: PC	(6)
d. Using a wiring diagram and multimeter, troubleshoot the cargo air conditioning system trainer locating a minimum of three out of four troubles correctly. STS: 16d(1) Meas: PC	(9)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-209, Cargo Air Conditioning System
C3ABR42331-PT-209A, Mercury Thermostat Temperature Control System
C3ABR42331-WB-209, Cargo Air Conditioning System Wiring Diagram
C3ABR42331-WB-209A, Cargo Air Conditioning System Troubleshooting

Audio Visual Aids
Transparency, CT 73-260, Mercury Thermostat System

Training Equipment
Trainer 3021, Cargo Air Conditioning System (1)
Multimeter (1)

Training Methods
Self-Instruction (7 hrs)
Performance (15 hrs)

Multiple Instructor Requirements
Supervision, Equipment (4)

Instructional Guidance
The instructor will issue workbook and training equipment to each student. Each student must satisfactorily accomplish the objectives before he/she can proceed to the next unit of instruction. The instructor will ensure that all training equipment used by the student is turned in and properly stored. Ensure student complies with safety practices IAW applicable AFOSH standards. Turn off all power when applicable to conserve energy and resources.

10.	Military Training	7
	a. Physical Conditioning	(6)
	b. Commander's Call	(1)
11.	Written Test and Critique	1.5

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
1. Maintenance Management	15
a. Identify the functions and responsibilities of the Deputy Commander for Maintenance (DCM) by answering a minimum of four of five questions correctly. STS: 6a Meas: PC	(2)
b. Identify the basic functions of the DCM's staff by answering a minimum of eight of ten questions correctly. STS: 6b Meas: PC	(2)
c. Identify facts relating to maintenance data collection by answering a minimum of four of five questions correctly. STS: 6c Meas: PC	(2.5)
d. Identify facts for processing and controlling material with 100% accuracy. STS: 6d Meas: PC	(2.5)
e. Given a narrative problem and applicable technical orders, correctly complete AFTO Forms 349, 350 and 781A. This will be done with a maximum of two instructor assists per form. STS: 7d Meas: PC	(2)
f. State general principles of the maintenance system by answering a minimum of eight of ten questions correctly. STS: 7a Meas: PC	(1)
g. State general principles of the inspection system by answering a minimum of eight of ten questions correctly. STS: 7b Meas: PC	(3)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

ATCPT 52-1, Volume 1, Organization and Functions
ATCPT 52-1, Volume 2, Aircraft Inspection and Maintenance System
ATCPT 52-1, Volume 3, Data Collection System
ATCPT 52-1, Volume 4, Reference Materials
ATCPT 52-1, Volume 5, Student Response Booklet
AFTO Form 349, Maintenance Data Collection Record
AFTO Form 350, Repairable Item Processing Tag

Training Methods

Self-Instruction (13 hrs)
Performance (2 hrs)

Instructional Guidance

Insure that AFTO Forms 349 and 350 are available for student use after completing Volume 3. When the 349 and 350 forms have been completed, the student will turn them in to be used for a progress check. Observe the students during class and insure they have completed all subject matter material before testing. Answer any questions that may arise. An instructor assist is defined as limited aid such as technical direction or explanation and/or technical order interpretation given to a student who can progress no further on his/her own. Turn off all power when applicable to conserve energy and resources.

When a group of students, 5 or more, are experiencing difficulty with this material and the instructor supervisor feels that individual assistance would cause a backlogging of students, group pace will be used.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR

COURSE TITLE
Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
2. Technical Order Publication Systems	9
a. State general principles of the technical order system by answering a minimum of eight of ten questions correctly. STS: 4a Meas: PC	(3)
b. Using applicable technical manuals, locate selected items of information for performing maintenance with a maximum of four instructor assists. STS: 4b(1) Meas: PC	(4)
c. Determine procedural instructions contained in time compliance technical orders by answering a minimum of eight of ten questions correctly. STS: 4c Meas: PC	(1)
d. Identify conditions that would require the initiation of a technical order improvement report answering a minimum of four of five questions correctly. STS: 4e Meas: PC	(1)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-302, Introduction to the Technical Order System
C3ABR42331-PT-302A, Technical Order System Indexes and Manuals
C3ABR42331-PT-302B, Technical Manuals (GA, MS, TS & JG)
C3ABR42331-WB-302, TO System Indexes and Manuals

Training Equipment
Training Technical Order (1)

Training Methods
Self-Instruction (6 hrs)
Performance (3 hrs)

Instructional Guidance
The instructor will ensure that all technical orders are properly signed out and returned to the training file in good repair. Observe the students during class and insure they have completed all subject matter before testing. Answer any questions that may arise. Turn off all power when applicable to conserve energy and resources.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
3. Tools, Hardware, Safetying Devices, and Wire Repair	21
a. Relate maintenance tools to their proper uses by answering a minimum of eight of ten questions correctly. STS: 8a Meas: PC	(4)
b. Using a trainer, applicable handtools, and workbook, torque aircraft type nuts according to specified values. STS: 8a Meas: PC	(2)
c. State the correct purpose of the consolidated toolkit (CTK) program. STS: 8d Meas: PC	(4)
d. Using mechanical safetying devices, trainer, workbook, and applicable handtools, safety bolts, clamps and connectors to TO specifications. STS: 8b, 8c Meas: PC	(6)
e. Specify general principles relating to the use of general purpose electrical hardware. A minimum of eight of ten must be correct. STS: 10d(1) Meas: PC	(1)
f. Using a trainer, workbook, applicable tools and equipment, solder wire to connectors and install electrical wiring IAW TO 1-1A-14. STS: 10d(2), 10d(3) Meas: PC	(4)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

C3ABR42331-PT-303, Maintenance Tools
C3ABR42331-WB-303, Torque Wrench Performance
C3ABR42331-PT-303A, Aircraft Hardware
C3ABR42331-WB-303A, Safetying Methods, Procedures and Devices
C3ABR42331-PT-303B, General Purpose Connectors, Bonding, Shielding and Grounding
C3ABR42331-WB-303B, Wiring Maintenance
TO 1-1A-8, Aircraft Structural Hardware
TO 1-1A-14, Aircraft Electric and Electronic Wiring

Audio Visual Aids

Film AVA 503, Soldering and Soldering Iron Preparation
Film AVA 505, Stripping and Crimping

Training Equipment

Trainer 4059, Torque Wrench Application (1)
Trainer 2301, Safetywire (1)
Trainer 4435, Wiring Maintenance (1)
Torque Wrench (1)
Soldering Iron (1)
Applicable Handtools (1)
Display Boxes:
  4115, Aircraft Bolts (1)
  4116, Aircraft Fittings (1)
  4117, Aircraft Fasteners (1)
  4118, Pliers (1)
  4119, Wrench (1)
  4120, Sockets (1)
  4121, Hammer (1)

Training Methods

Self-Instruction (9 hrs)
Performance (12 hrs)

Instructional Guidance

The instructor will give each student an orientation relative to laboratory procedures and will conduct individual assistance as required. Students are required to use wire maintenance trainers, safety wire trainers, soldering equipment, and torque wrenches to complete assigned projects. The instructor guides and assists the students and performs progress checks. Turn off all power when applicable to conserve energy and resources.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
4. Maintenance of Moisture Separators	3
a. Relate components of the moisture separator to their operation by answering a minimum of eight of ten questions correctly. STS: 16a(3) Meas: PC	
b. Using a TO, applicable handtools, AFTO Forms 349, and equipment, disassemble, inspect, and reassemble a moisture separator with a maximum of four instructor assists. STS: 4b(1), 4b(2), 7c Meas: PC	

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-304, Operation of an Aircraft Air Conditioning System Moisture Separator
C3ABR42331-WB-304, Maintenance of Moisture Separators
AFTO Form 349, Maintenance Data Collection Record
TO 1C-130A-06, Work Unit Code Manual
TO 15A7-2-11-3, Moisture Separator

Training Equipment
Moisture Separator (1)
Applicable Handtools (1)

Training Methods
Self-Instruction (1 hr)
Performance (2 hrs)

Instructional Guidance
The laboratory instructors will provide assistance on an individual basis as required and ensure that each objective is accomplished. An instructor assist is defined as limited aid such as technical direction or explanation and/or technical order interpretation given a student who can proceed no further on his/her own. Turn off all power when applicable to conserve energy and resources.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
5. Maintenance of Bleed Air Distribution Ducting	3

a. Determine procedures for repairing bleed air duct insulation by answering a minimum of four of five questions correctly. STS: 15h Meas: PC

b. Identify methods used to slow corrosion on bleed air ducting by answering a minimum of four of five questions correctly. STS: 10a Meas: PC

c. Relate types of cleaning agents and lubricants to their uses by answering a minimum of four of five questions correctly. STS: 10b Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

C3ABR42331-PT-305, Maintenance of Bleed Air Distribution Ducting

Training Equipment

Aircraft Ducting (1)

Training Methods

Self-Instruction (2 hrs)
Performance (1 hr)

Instructional Guidance

The instructor will make sure the PT and section of aircraft ducting are available for the student to use. Observe student's progress on the objectives and provide individual assistance as necessary. Answer any questions that may arise. Turn off all power when applicable to conserve energy and resources.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircräft Environmental Systems Mechanic
BLOCK TITLE Environmental Systems Units	

1. COURSE CONTENT	2. TIME
6. Air Turbine Motor Maintenance	3

a. State general principles relating to the operation of the air turbine motor by answering a minimum of eight of ten questions correctly. STS: 19a Meas: PC

b. Given applicable workbook, AFTO forms, TO, and necessary equipment, perform a minor inspection of the air turbine motor, locating a minimum of two discrepancies, with a maximum of four instructor assists. STS: 19b Meas: PC

*c. Given a workbook, AFTO forms, TO, and necessary equipment, and using a source of hot pressurized air, perform an operational check on the air turbine motor with a maximum of four instructor assists. STS: 3d, 19c Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-306, Air Turbine Motors
C3ABR42331-WB-306, Maintenance of Air Turbine Motors
TO 1C-130A-06, Work Unit Code Manual
AFTO Form 26, Inspection Workcard
AFTO Form 349, Maintenance Data Collection Record

Training Equipment
Ear Protectors (1)
Air Turbine Motor (2)
Head Set, Microphone (1)

Training Methods
Self-Instruction (1 hr)
Performance (2 hrs)

Instructional Guidance
The classroom instructor will observe students in class and insure subject material is completed before testing. Answer any questions that may arise. The laboratory instructor will orient each student to the laboratory situation, and brief students on safety hazards and precautions and conservation of energy and materials. Stress danger areas when working with hot compressed air. Also, insure that each student has ear protectors when working in high intensity noise areas. Observe student's performance while completing the workbook and provide individual assistance as required. Have students record work on maintenance data forms. Assure each objective is covered. An instructor assist is defined as limited aid such as technical direction or explanation and/or technical order interpretation, given to a student who can progress no further on his/her own. Turn off all power when applicable to conserve energy and resources.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
7. Advanced Fighter-Bomber Air Source Control System	11
a. Relate components of the advanced fighter-bomber air source control system to their operation by answering a minimum of eight of ten questions correctly. STS: 15a Meas: PC	(1.5)
b. Given an advanced fighter-bomber air source wiring diagram, relate components to their operation by identifying causes of system malfunctions. A minimum of eight of ten must be correct. STS: 15a, 15d Meas: PC	(5.5)
c. Given the applicable wiring diagram, workbook, TO, AFTO forms, and multimeter, and working in a group of not more than two students, troubleshoot malfunctions on the advanced fighter-bomber air source control system trainer, locating the cause for three of four malfunctions correctly. STS: 15d Meas: PC	(4)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

C3ABR42331-PT-307, Advanced Fighter/Bomber Air Source Control System
C3ABR42331-WB-307, Advanced Fighter/Bomber Air Soruce Control System Operational Check and Troubleshooting
C3ABR42331-WB-307A, Advanced Fighter/Bomber Air Source Control System
TO 1F-111A-06, Work Unit Code Manual
AFTO Form 781A, Maintenance Discrepancy and Work Document
AFTO Form 349, Maintenance Data Collection Record

Training Equipment

Trainer 4024, Advanced Fighter/Bomber Air Conditioning System (1)
Multimeter (1)

Training Methods

Self-Instruction (1.5 hrs)
Performance (9.5 hrs)

Instructional Guidance

The classroom instructor will observe students in class and insure subject material is completed before testing Answer any questions that may arise. The laboratory instructor will orient each student to the laboratory situation and brief the students on safety hazards and precautions and conservation of energy and materials. Observe students performance while completing the workbook and provide individual assistance as required. Have students record work on maintenance data forms. Assure each objective is covered. Turn off all power when applicable to conserve energy and resources.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
8. Advanced Fighter-Bomber Air Conditioning System	15
a. Relate components of the advanced fighter-bomber air conditioning system to their operation by answering a minimum of eight of ten questions correctly. STS: 16a(2) Meas: PC	(4)
b. Given an advanced fighter-bomber air conditioning system wiring diagram, relate components to their operation by identifying causes of system malfunctions. A minimum of eight of ten must be correct. STS: 13e(1), 16a(2) Meas: PC	(4)
c. Given the applicable wiring diagram, AFTO forms, workbook, and multimeter, and working in a group of not more than two students, troubleshoot malfunctions on the advanced fighter-bomber air conditioning system trainer by locating the cause for three of four malfunctions correctly. STS: 13e(1) Meas: PC	(4)
*d. Given workbook, AFTO forms, TO, equipment, and source of hot pressurized air, and working in a group of not more than two students, perform an operational check on the air conditioning system of the CT-5 air conditioning system trainer with a maximum of four instructor assists. STS: 3d, 15i, 16c Meas: PC	(3)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-309, Fighter/Bomber Air Conditioning System
C3ABR42331-WB-309, Component, Identification, Operational Check and Troubleshooting
C3ABR42331-WB-309A, Fighter/Bomber Temperature Control Wiring Diagram
TO 1F-111A-06

Training Equipment
Trainer, 4024, Advanced Fighter/Bomber Air Conditioning System (2)
Trainer CT5, Environmental Systems (2)
Ear Protectors (1)
Multimeter (1)
Head Set, Microphone (1)

Training Methods
Self-Instruction (4 hrs)
Performance (11 hrs)

Instructional Guidance
The classroom instructor will observe students in class and insure subject material is completed before testing. Answer any questions that may arise. The laboratory instructor will orient each student to the laboratory situation, and brief students on safety hazards and precautions and conservation of energy and materials. Stress danger areas when working with hot compressed air. Also, ensure that each student has ear protectors when working in high intensity noise areas. Observe students performance while completing the workbooks, and provide individual assistance as required. Have students record work on maintenance data forms. Assure each objective is covered. Turn off all power when applicable to conserve energy and resources.

9. Written Test and Critique 2

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
10. Advanced Fighter-Bomber Windshield Clearing System	10
a. Relate advanced fighter-bomber rain remover system components to their operation by answering a minimum of eight of ten questions correctly. STS: 17a(4) Meas: PC	(1)
b. Given an advanced fighter-bomber rain removal system wiring diagram, relate components to their operation by identifying causes of system malfunctions. A minimum of eight of ten must be correct. STS: 17a(4), 17d Meas: PC	(5)
c. Given the applicable wiring diagram, workbook, TO, AFTO forms, multimeter, and working in a group of not more than two students, troubleshoot malfunctions on the advanced fighter-bomber rain removal system trainer by locating the cause for a minimum of three of four malfunctions correctly. STS: 17d Meas: PC	(4)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-310, Fighter/Bomber Windshield Clearing System
C3ABR42331-WB-310, Advanced Fighter/Bomber Windshield Clearing System
C3ABR42331-WB-310A, Fighter/Bomber Windshield Clearing System
AFTO Form 781A, Maintenance Discrepancy and Work Document
AFTO Form 349, Maintenance Data Collection Record
TO 1F-111A-06

Training Equipment
Trainer 4024, Advanced Fighter/Bomber Air Conditioning System (1)
Multimeter (1)

Training Methods
Self-Instruction (1 hr)
Performance (9 hrs)

Instructional Guidance
The classroom instructor will observe students in class and insure subject material is completed before testing. Answer any questions that may arise. The laboratory instructor will brief each student on safety hazards and precautions and conservation of energy and materials. Observe students performance while completing the workbooks and provide individual assistance as required. Have students record work on maintenance data collection forms. Assure each objective is covered. Turn off all power when applicable to conserve energy and resources.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
11. Maintenance of Air Control Units	14
a. State the principle of air flow measurement with 100% accuracy. STS: 11f Meas: PC	(2)
b. Relate components of selected air control units to their operation by answering a minimum of eight of ten questions correctly. STS: 15a Meas: PC	(2)
c. Given the electric/pneumatic components tester, applicable handtools, TO, workbook, AFTO forms, and working in a group of not more than two students, bench check selected air control units with a maximum of two instructor assists for each unit checked. STS: 14c, 15g Meas: PC	(4)
d. Relate components of the air flow control and shutoff valve to their principles of operation by answering a minimum of eight of ten questions correctly. STS: 11e Meas: PC (W)	(3)
e. Given the electric-pneumatic component tester, applicable handtools, AFTO forms, TO, and workbook, and working in a group of not more than two students, bench check and repair an air flow control and shutoff valve with a maximum of two instructor assists. STS: 16g, 16h Meas: PC (P)	(3)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

C3ABR42331-PT-311, Air Control Valves
C3ABR42331-PT-311A, Principles of Airflow Control and Shutoff Valve
C3ABR42331-WB-311, Bench Testing Electric Motor Actuated Valves
C3ABR42331-WB-311A, Airflow Control and Shutoff Valve
AFTO Form 349, Maintenance Data Collection Record
AFTO Form 350, Repairable Item Processing Tag
TO 1B-52G-06, Work Unit Code Manual
TO 1C-130A-06, Work Unit Code Manual
TO 9P5-5-59-43, Two and One-Half Inch Diameter Pneumatic Shutoff Valve
TO 9P5-14-3-3, Two and One-Half Inch Diameter Shutoff Air Flow Regulator
TO 15A2-2-20-193, Two and One-Half Inch Diameter Shutoff Air Flow Regulator
TO 15A2-2-52-83, Motor Actuated Butterfly Shutoff Valve Assembly
TO 15A2-2-92-3, Power Operated Butterfly Valve

Training Equipment

Trainer 3038, Electric/Pneumatic Component (1)
Applicable Aircraft Valves (1)
Applicable Handtools (1)
Multimeter (1)

Training Methods

Self-Instruction (7 hrs)
Performance (7 hrs)

Instructional Guidance

The classroom instructor will observe students during class and provide individual assistance as required. Ensure subject material is completed before testing and answer any questions that may arise. Assure that the objectives are covered. The laboratory instructor will orient the students to the laboratory situation and brief them on safety hazards and precautions. Provide individual assistance as required and assure objectives are covered. An instructor assist is defined as limited aid such as technical direction or explanation and/or technical order interpretation, given to a student who can progress no further on his own. Turn off all power when applicable to conserve energy and resources.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
12. Anti-G Suit System	2

a. Relate components of anti-G suit valve to their operation by answering a minimum of eight of ten questions correctly. STS: 17a(1) Meas: PC

b. Given a ground laboratory test kit, electric/pneumatic component tester, applicable handtools, TO, and workbook, and working in a group of not more than two students, bench check and repair an anti-G suit valve with a maximum of two instructor assists. STS: 17g, 17h Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

C3ABR42331-PT-312, Principles of Anti-G System
C3ABR42331-WB-312, Maintenance of Anti-G Suit Valve
TO 9P5-3-12-3, Anti-G Suit Valve

Training Equipment

Trainer 4058, Anti-G Suit Valve (1)
Trainer 3038, Electric-Pneumatic Component (1)
Test Kit P/N 10670, Ground Laboratory (1)
Applicable Handtools (1)

Training Methods

Self-Instruction (1 hr)
Performance (1 hr)

Instructional Guidance

The classroom instructor will insure that the cutaway display of the anti-G suit valve is available for student use. Provide individual assistance as required and insure subject material is completed before testing. Answer any questions that may arise. Assure that the objective is covered. The laboratory instructor will brief students on safety hazards and precautions, and provide individual assistance as required, and assure the objectives are accomplished. An instructor assist is defined as limited aid such as technical direction or explanation and/or technical order interpretation, given a student who can proceed no further on his/her own. Turn off all power when applicable to conserve energy and resources.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
13. Canopy Seal System	4

a. Relate components of the canopy seal pressurization system to their operation by answering a minimum of eight of ten questions correctly. STS: 17a(2) Meas: PC

b. Given the electric/pneumatic component tester, applicable handtools, TO, and workbook, and working in a group of not more than two students, bench check and repair a canopy seal pressure regulator with a maximum of two instructor assists. STS: 17g, 17h Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-313, Canopy Seal System
C3ABR42331-WB-313, Maintenance of Canopy Seal Regulators
TO 16R1-4-2-3, Overhaul Instructions with Illustrated Parts Breakdown Canopy Seal Pressure Regulator

Training Equipment
Trainer 3038, Electric-Pneumatic Component (1)
Canopy Seal Regulator (1)
Applicable Handtools (1)

Training Methods
Self-Instruction (1 hr)
Performance (3 hrs)

Instructional Guidance
The classroom instructor will observe students during class and provide individual assistance as required. Ensure subject material is completed before testing. Assure the objective is covered. The laboratory instructor will insure safety precautions are followed and provide individual assistance when necessary. An instructor assist is defined as limited aid such as technical direction or explanation and/or technical order interpretation, given to a student who can progress no further on his/her own. Turn off all power when applicable to conserve energy and resources.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
14. Pressurization Systems	15
a. Relate the components of the pressurization system to their operation by answering a minimum of eight of ten questions correctly. STS: 18a Meas: PC	(9)
b. Relate components of a pneumatic control circuit to their operation by answering a minimum of four of five questions correctly. STS: 13b Meas: PC	(3)
c. Identify procedures used to troubleshoot a pneumatic control circuit by answering a minimum of four of five questions correctly. STS: 13e(2) Meas: PC	(3)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-314, Pressurization Principles
C3ABR42331-PT-314A, Pneumatic Control Circuits
C3ABR42331-HO-314, Troubleshooting Pneumatic Control Circuits

Audio Visual Aids
Film LFC 4212, Pressurization Principles
Film LFC4213, Bomber Aircraft Pressurization Systems
Film LFC 4233, Fighter Pressure Regulator

Training Methods
Self-Instruction (15 hrs)

Instructional Guidance
The classroom instructor will tell the students to watch training film LFC 4212 before they begin pressurization principles and to watch films LFC 4213 and LFC 4233 before they start each new PT on bomber and fighter pressurization. The instructor will ensure all necessary material is available for student use. He/She will observe students in class and insure subject material is completed before testing. Answer any questions that may arise. Turn off all power when applicable to conserve energy and resources.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Environmental Systems Units

1. COURSE CONTENT	2. TIME
15. Cabin Pressure Leakage Check	4

a. Given the applicable TO and workbook, relate the controls on the cabin pressure leakage tester to their function with 80% accuracy. STS: 14f Meas: PC

*b. Given a workbook, and working in a group of not more than four students, perform an operational check on the CT-5 trainer with a maximum of four instructor assists. STS: 18c Meas: PC

*c. Given a cabin pressure leakage tester, consolidated tool kit, and workbook, and working in a group of not more than four students, perform a cabin pressure leakage test on the CT-5 trainer with no more than six instructor assists. STS: 8e, 14f, 18i Meas: PC

*d. Given a workbook, troubleshoot the CT-5 trainer, with no more than three instructor assists. STS: 18d Meas: PC

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-WB-315, Operation of MB-3 Leakage Tester
C3ABR42331-WB-315A, Cabin Pressure Leakage Check
TO 1F-111A-2-2-1, Airframe and Related System
TO 33A4-4-10-1, Portable Electric Motor Driven Pressurized Cabin Leakage Tester, Type MB-3

Training Equipment
Trainer CT-5, Environmental Systems or Aircraft (4)
Safety Net (4)
Warning Signs (4)
MB-3 Cabin Leakage Tester (4)
Tool Box (4)
Head Set, Microphone (1)

Training Methods
Performance (4 hrs)

Instructional Guidance
The instructor will orient students to the laboratory situation and brief students on danger areas and noise protection. Provide individual assistance as required and assure objectives are accomplished. An instructor assist is defined as limited aid such as technical direction or explanation and/or technical order interpretation given to a student who can proceed no further on his own. Turn off all power when applicable to conserve energy and resources.

16.	Military Training	9
	a. Physical Conditioning	(8)
	b. Commander's Call	(1)
17.	Written Test and Critique	2

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Utility Systems and Flight-Line Maintenance

1. COURSE CONTENT	2. TIME
1. Gaseous Oxygen System	3
a. State general principles relating to the operation of a gaseous oxygen system. A minimum of four out of five must be correct. STS: 20a(1) Meas: PC	(3)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

C3ABR42331-PT-401, Low and High Pressure Systems

Training Methods

Self-Instruction (3 hrs)

Instructional Guidance

The instructor will instruct/supervise the student class study period, continually administer, evaluate and critique progress checks as each student progresses, ensure the student has correct module materials, record student progress, counsel student as needed regarding academic and nonacademic reasons, monitor breaks and clean-up periods. The instructor will provide individual assistance to each student as needed during class. Each student must satisfactorily complete the appraisal to satisfy the objective(s). The instructor will pick up all reusable training literature from the student(s) as feasible. Turn off all power when applicable to conserve energy and resources. The instructor will refer to Part II Teaching Guide for detailed instructions on this module.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Utility Systems and Flight-Line Maintenance

1. COURSE CONTENT	2. TIME
2. Liquid Oxygen Systems	3.5
a. State general principles relating to the operation of a liquid oxygen system. A minimum of four out of five must be correct. STS: 20a(2) Meas: PC	(3.5)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-402, Liquid Oxygen Systems

Training Methods
Self-Instruction (3.5 hrs)

Instructional Guidance
The instructor will instruct/supervise the student class study period, continually administer, evaluate and critique progress checks as each student progresses, ensure the student has correct module materials, record student progress, counsel student as needed regarding academic and nonacademic reasons, monitor break and clean-up periods. The instructor will provide individual assistance to each student as needed during class. Each student must satisfactorily complete the progress check to satisfy the objective(s). The instructor will pick up all reusable training literature from the student(s) as feasible. Turn off all power when applicable to conserve energy and resources. The instructor will refer to Part II Teaching Guide for detailed instructions on this module.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic

BLOCK TITLE
Utility Systems and Flight-Line Maintenance

1. COURSE CONTENT	2. TIME
3. Inspection and Maintenance of Liquid Oxygen Systems	16
a. Using trainer, safety equipment and workbook, perform an operational check of a liquid oxygen system. A maximum of one instructor assist is allowed. Apply safety precautions without error. STS: 20c, 201(2) Meas: PC	(2)
b. Given a trainer, applicable TOs, and workbook, use a sonic leak detector to leak check a liquid oxygen system. A maximum of one instructor assist is allowed. Apply safety precautions without error. STS: 14e Meas: PC	(2)
c. Given a liquid oxygen system schematic and malfunctions, correctly identify four out of five causes. STS: 20d Meas: PC	(2)
d. Using the necessary tools, equipment, applicable TOs, and workbook, repair selected components of an oxygen system. A maximum of one instructor assist per component, is allowed. Apply safety precautions without error. STS: 10c, 20h, 201(1), 201(2) Meas: PC	(3)
e. Given applicable TOs and workbook, use a TTU/162E converter tester to bench check a liquid oxygen converter. A maximum of one instructor assist is allowed. Apply safety precautions without error. STS: 14d(1), 20g, 201(1), 201(2) Meas: PC	(3)
f. Given applicable TOs and workbook, use a regulator tester to perform an operational check of an oxygen regulator. A maximum of one instructor assist is allowed. Apply safety precautions without error. STS: 14d(2) Meas: PC	(2)
g. Given a trainer, applicable TOs, and workbook, use a quantity indicator capacitance tester and bench check the converter capacitance system. A maximum of one instructor assist is allowed. Apply safety precautions without error. STS: 14d(3), 20g Meas: PC	(2)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-403, Oxygen Systems Safety
C3ABR42331-WB-403, Oxygen Systems Laboratory Projects
AFTO Form 26, Inspection Workcard
AFTO Form 349, Maintenance Data Collection Record
TO 1T-38A-06, Work Unit Code Manual
TO 15X1-1-1, Oxygen Equipment
TO 33D2-6-182-11, Capacitance Type Liquid Quantity System Test Set
TO 33D2-10-46-1, Tester, Liquid Oxygen Converter System
TO 33D2-10-55-1, Oxygen Regulator Field Tester
TO 33E2-3-3-1, Liquid Oxygen Converter System Purging Kit
TO 33D9-84-30-1, Sonic Leak Detector
TO 15X6-3-63, 10 Liter Converter

Training Equipment
Oxygen Safety Equipment (1)
CTK (1)
Sonic Leak Detector (2)
Oxygen Converter (2)
TTU/162E Converter Tester (2)
Hot Purge Kit (2)
TF-20-1 Capacitance Tester (2)
Trainer 18754490, Liquid Oxygen Systems (2)
Oxygen Regulator Field Tester (2)

Training Methods
Performance (16 hrs)

Instructional Guidance
The lab instructor will supervise the lab period, continually administer, evaluate and critique performance exercises as each student progresses, ensure student has correct module materials and equipment, record student's progress, counsel student as needed regarding academic and nonacademic reasons, monitor breaks and clean-up periods, ensure student complies with safety practices IAW applicable AFOSH standards. The instructor will provide individual assistance to each student as needed during lab projects. Each student must satisfactorily complete the individual performance exercises to satisfy the objectives. The instructor will pick up all reusable training literature from the student as feasible. Turn off all power as applicable to conserve energy and resources. The instructor will refer to Part II Teaching Guide for detailed instructions on this module. An instructor assist is defined as limited aid, such as technical direction or explanation and/or technical order interpretation given a student who can proceed no further on his/her own. A detected safety violation (DSV) is an automatic failure for that objective.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Utility Systems and Flight-Line Maintenance

1. COURSE CONTENT	2. TIME
4. Cryotainer Systems Maintenance	24
a. State general principles relating to the operation of the cryotainer system and units. A minimum of four out of five must be correct. STS: 24a Meas: PC	(4)
b. Using tools, inspection workcard, applicable TOs, and workbook, inspect the cryotainer and components. Locate a minimum of four discrepancies and record on AFTO Forms 349. A maximum of two instructor assists is allowed. Apply safety precautions without error. STS: 4d(1), 24d, 24e, 24k Meas: PC	(3)
c. Using assigned cryotainer, proper tools, applicable TOs, and workbook, remove and replace a minimum of three components. A maximum of one instructor assist per component is allowed. Apply safety precautions without error. STS: 24h, 24i, 24k Meas: PC	(5)
d. Using a vacuum pump, vacuum micron gage, applicable TOs, workbooks, and working in a group of not more than four students, evacuate a cryotainer. A maximum of three instructor assists is allowed. Apply safety precautions without error. STS: 24b, 24k Meas: PC	(3)
e. Using purging unit, applicable TOs, workbook, safety equipment, and working in a group of not more than four students, purge a cryotainer. A maximum of two instructor assists is allowed. Apply safety precautions without error. STS: 24c, 24k Meas: PC	(3)
f. Using safety equipment, applicable TOs, workbook, and working in a group of not more than two students, perform an operational test of a cryotainer. A maximum of two instructor assists is allowed. Apply safety precautions without error. STS: 24f, 24k Meas: PC	(3)
g. Using leak tec solution, sonic leak detector, safety equipment, applicable TOs, workbook, and working in a group of not more than two students, perform leak tests on a cryotainer. A maximum of one instructor assist is allowed. Apply safety precautions without error. STS: 14e, 24g, 24k Meas: PC	(3)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

C3ABR42331-PT-404, Cryotainer Systems
C3ABR42331-WB-404, Cryotainer Laboratory Projects
AFTO Form 26, Inspection Workcard
AFTO Form 349
TO 00-25-06-2-2, Work Unit Code Manual
TO 37C2-8-1-101, Liquid Oxygen, Nitrogen and Argon Storage and Transfer Tanks
TO 37C2-8-3-3, 50 Gallon Liquid Oxygen Storage and Transfer Tank
TO 37C11-3-1, Vacuum Gauge
TO 37C2-8-3-4, 50 Gallon Liquid Oxygen and Liquid Nitrogen Storage and Transfer Tank
TO 36G2-3-1, Air Purging Unit Type GSU-62/M
TO 34Y5-3-37-11, Vacuum Pump, Rotary Power Driven USAF Type PMU-4/E
TO 33D9-84-30-1, Sonic Leak Detector

Training Equipment

Cryotainers (4)
Purge Unit (4)
Vacuum Pump (4)
Micron Gage (4)
Safety Equipment (1)
CTK (1)
Sonic Leak Detector (1)

Training Methods

Self-Instruction (3.5 hrs)
Performance (20.5 hrs)

Instructional Guidance

The classroom and/or lab instructor will supervise the student class study and/or lab period, continually administer, evaluate and critique progress checks and performance exercises as each student progresses, ensure student has correct module materials and equipment, record student's progress, counsel student as needed regarding academic and nonacademic reasons, monitor breaks and clean-up periods, ensure student complies with safety practices IAW applicable AFOSH standards. The instructor will provide individual assistance to each student as needed during class/lab period. Each student must satisfactorily complete the individual progress checks and/or performance exercise to satisfy the objectives. An instructor assist is defined as limited aid such as technical direction or explanation and/or technical order interpretation for the student who can proceed no further on his/her own. A detected safety violation is an automatic failure for this objective. Stress danger areas when working with hot compressed air and high pressure gases. Also, ensure that each student has ear protectors when working in high intensity noise areas. The instructor will pick up all reusable training literature from the student as feasible. Turn off power when applicable to conserve energy and resources. The instructor will refer to Part II Teaching Guide for detailed instructions on this module.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR

COURSE TITLE
Aircraft Environmental Systems Mechanic

BLOCK TITLE
Utility Systems and Flight-Line Maintenance

1. COURSE CONTENT	2. TIME
5. Life Raft Inflation Equipment	5.5
a. State general principles relating to the operation of life raft inflation equipment. A minimum of four out of five must be correct. STS: 22a Meas: PC	(1.5)
b. Using tools, applicable TOs and workbook, inspect the valve head assemblies and cylinders. Locate a minimum of four discrepancies and record them on AFTO Forms 349. A maximum of two instructor assists is allowed. Apply safety precautions without error. STS: 22c Meas: PC	(2)
c. Using the life raft inflation cylinder recharging equipment, scales, tools, applicable TOs, workbook, and working in a group of not more than two students, service a life raft cylinder IAW TO tolerances and discharge cylinder safely. A maximum of three instructor assists is allowed. Apply safety precautions without error. STS: 3h, 22b, 22e, 22f(1), 22f(2) Meas: PC	(2)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-405, Life Raft Inflation Equipment
C3ABR42331-WB-405, Inspection and Servicing of Life Raft Cylinders
TO 00-25-06-2-1, Work Unit Code Manual
TO 14S1-1-102, USAF Flotation Equipment
TO 14S1-1-33, Life Raft Inflation Equipment
AFTO Form 349
AFTO Form 26

Training Equipment
Carbon Dioxide Recharging Pump (2)
Scale-Dial and Beam (2)
Life Raft Inflation Cylinder (2)
CTK (1)

Training Methods
Self-Instruction (2.5 hrs)
Performance (3 hrs)

Instructional Guidance

The classroom and/or lab instructor will supervise the student class study and/or lab period, continually administer, evaluate and critique progress checks and performance exercises, as each student progresses. Ensure student has correct module materials and equipment, record student's progress, counsel student as needed regarding academic and nonacademic reasons, monitor breaks and clean-up periods, ensure student complies with safety practices IAW applicable AFOSH standards. The instructor will provide individual assistance to each student as needed during class/lab periods. Each student must satisfactorily complete the individual progress checks and/or performance exercise to satisfy the objectives. An instructor assist is defined as limited aid such as technical direction or explanation and/or technical order interpretation given a student who can proceed no further on his/her own. A detected safety violation is an automatic failure for that objective. The instructor will pick up all reusable training literature from the student as feasible. Turn off all power when applicable to conserve energy and resources. The instructor will refer to Part II Teaching Guide for detailed instructions on this module.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Utility Systems and Flight-Line Maintenance

1. COURSE CONTENT	2. TIME
6. Fire Extinguisher System Maintenance	8
a. State general principles relating to the operation of aircraft fire extinguishing release systems. A minimum of four out of five must be correct. STS: 21a(1) Meas: PC	(1)
b. State general principles relating to the operation of aircraft fire extinguishing directional systems. A minimum of four out of five must be correct. STS: 21a(2) Meas: PC	(1)
c. State procedures for repairing components of a fire extinguishing system. A minimum of four out of five must be correct. STS: 21h Meas: PC	(.5)
d. State procedures relating to the servicing of fire extinguishing systems. A minimum of four out of five must be correct. STS: 21i Meas: PC	(.5)
e. Specify, without error, safety precautions involved in handling inert gases. STS: 21j(1) Meas: PC	(.5)
f. Specify, without error, safety precautions involved in handling toxic compounds. STS: 21j(2) Meas: PC	(.5)
g. Specify, without error, safety precautions involved in handling explosive squibs. STS: 21j(3) Meas: PC	(.5)
h. Specify, without error, safety precautions involved in handling high pressure gases. STS: 21j(4) Meas: PC	(.5)
i. Using a fire extinguishing trainer, inspection workcard, -06 code book and workbook, inspect the fire extinguishing system. Locate a minimum of five discrepancies and record on AFTO Forms 349. A maximum of three instructor assists is allowed. Apply safety precautions without error. STS: 21b Meas: PC	(1)
j. Using a fire extinguishing trainer and workbook, perform an operational check of the fire extinguishing system. A maximum of one instructor assist is allowed. Apply safety precautions without error. STS: 21c Meas: PC	(.5)

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k. Using a fire extinguisher trainer, multimeter and workbook, troubleshoot a fire extinguishing system for malfunctions. Locate and record a minimum of four out of five causes correctly. A maximum of two instructor assists is allowed. Apply safety precautions without error. STS: 21d Meas: PC (1)

l. Using container, ignition circuit tester, and workbook, bench check two squibs for proper resistance values. A maximum of one instructor assist is allowed. Apply safety precautions without error. STS: 21g Meas: PC (.5)

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

C3ABR42331-PT-406, Aircraft Fire Extinguishing Liquid Agent Systems
C3ABR42331-PT-406A, Aircraft Fire Extinguishing Systems Safety, Servicing, Repair,
C3ABR42331-WB-406, Aircraft Fire Extinguishing Laboratory Projects
AFTO Form 26
AFTO Form 349
TO 1C-141A-06, Work Unit Code Manual

Audio Visual Aids

Film AVA C-141, Fire Extinguishers

Training Equipment

Trainer 3180, Fire Extinguishing System (2)
Container and Squib (2)
Multimeter (2)
Igniter Tester (2)

Training Methods

Self-Instruction (3.5 hrs)
Performance (4.5 hrs)

Instructional Guidance

The classroom and/or lab instructor will supervise the student class study and/or lab period, continually administer, evaluate, and critique progress checks and performance exercises, as each student progresses, ensure student has correct module materials and equipment, record student progress, counsel student as needed regarding academic and nonacademic reasons, monitor breaks and clean-up periods, ensure student complies with safety practices IAW applicable AFOSH standards. The instructor will provide individual assistance to each student as needed during class/lab periods. Each student must satisfactorily complete the individual progress checks, and/or performance exercises, to satisfy the objectives. An instructor assist is defined as limited aid such as technical direction or explanation and/or technical order interpretation given a student who can proceed no further on his/her own. The instructor will pick up all reusable training literature as feasible. Turn off all power when applicable to conserve energy and resources. The instructor will refer to Part II Teaching Guide for detailed instructions on this module.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Utility Systems and Flight-Line Maintenance

1. COURSE CONTENT	2. TIME
7. Liquid Refrigeration Systems and Components	12.5
a. Identify the purpose of components in a liquid coolant system. A minimum of four out of five must be correct. STS: 23a(1) Meas: PC	(2.5)
b. Identify the purpose of components in a liquid cycle system. A minimum of four out of five must be correct. STS: 23a(2) Meas: PC	(3)
c. Using a refrigeration trainer, inspection workcard and workbook, inspect a liquid cycle refrigeration system. Locate a minimum of two discrepancies and record on AFTO Forms 349. A maximum of one instructor assist is allowed. Apply safety precautions without error. STS: 23b, 23i Meas: PC	(3)
d. Using a refrigeration trainer, manifold gage, workbook, and safety equipment, perform an operational check of a liquid cycle refrigeration system. A maximum of two instructor assists is allowed. Apply safety precautions without error. STS: 23c, 23i Meas: PC	(2)
e. Given a liquid cycle refrigeration schematic and malfunctions, correctly identify four out of five causes. STS: 23d Meas: PC	(2)

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-407, Liquid Coolant Systems
C3ABR42331-PT-407A, Liquid Cycle Refrigeration System
C3ABR42331-WB-407, Liquid Refrigeration Laboratory Projects
AFTO Form 26
AFTO Form 349
TO 1B-52H-06, Work Unit Code Manual

Audio Visual Aids
Film TF 5536B, Principles of Refrigeration

Training Equipment
Trainer 4369 Liquid Refrigeration System (2)
Manifold Gage Assembly (2)
Safety Equipment (1)

Training Methods
Self-Instruction (3.5 hrs)
Performance (9 hrs)

Instructional Guidance
The classroom and/or lab instructor will supervise the student class study and/or lab period, continually administer, evaluate and critique progress checks and performance exercises, as each student progresses, ensure student has correct module material and equipment, record student's progress, counsel student as needed regarding academic and nonacademic reasons, monitor breaks and clean-up periods, ensure student complies with safety practices IAW applicable AFOSH standards. The instructor will provide individual assistance to each student as needed during the class/lab periods. Each student must satisfactorily complete the individual progress checks and/or performance exercises to satisfy the objectives. An instructor assist is defined as limited aid such as technical direction or explanation and/or technical order interpretation given a student who can proceed no further on his/her own. A detected safety violation is an automatic failure for this objective. The instructor is to insure each student wears eye protection during the handling of Freon to prevent possible blinding of the student. The instructor will pick up all reusable training literature from the student as feasible. Turn off all power when applicable to conserve energy and resources. The instructor will refer to Part II Teaching Guide for detailed instructions on this module.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE Aircraft Environmental Systems Mechanic
BLOCK TITLE Utility Systems and Flight-Line Maintenance	

1. COURSE CONTENT	2. TIME
8. USAF Graduate Evaluation Program	1
a. Identify facts relating to the USAF Graduate Evaluation Program. A minimum of four out of five must be correct. STS: 5 Meas: None	(1)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

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C3ABR42331 000	IV	8	6 July 1983	115

FC JUN 8 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials
C3ABR42331-PT-408, USAF Graduate Evaluation Program

Training Methods
Self-Instruction (1 hr)

Instructional Guidance
The student will complete the USAF Graduate Evaluation Program programmed text. Turn off all power when applicable to conserve energy and resources.

9. Written Test and Critique 1.5

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Utility Systems and Flight-Line Maintenance

1. COURSE CONTENT	2. TIME
10. Flightline Maintenance, Inspection	16
a. Using an inspection workcard, assigned aircraft, and applicable TOs, inspect the bleed air distribution system. Locate a minimum of four discrepancies and record on AFTO Forms 349. A maximum of two instructor assists is allowed. Apply safety precautions without error. STS: 3c, 4d(2), 15b Meas: PC	(3)
b. Using an inspection workcard, assigned aircraft, and applicable TOs, inspect the air conditioning system. Locate a minimum of four discrepancies and record on AFTO Forms 349. A maximum of two instructor assists is allowed. Apply safety precautions without error. STS: 16b Meas: PC	(4)
c. Using an inspection workcard, assigned aircraft, and applicable TOs, inspect the auxiliary air systems. Locate a minimum of four discrepancies and record on AFTO Forms 349. A maximum of two instructor assists is allowed. Apply safety precautions without error. STS: 17b Meas: PC	(3)
d. Using an inspection workcard, assigned aircraft, and applicable TOs, inspect the pressurization system. Locate a minimum of two discrepancies and record on AFTO Forms 349. A maximum of one instructor assist is allowed. Apply safety precautions without error. STS: 18b Meas: PC	(3)
e. Using an inspection workcard, assigned aircraft and applicable TOs, inspect the oxygen system. Locate a minimum of four discrepancies and record on AFTO Forms 349. A maximum of two instructor assists is allowed. Apply safety precautions without error. STS: 20b Meas: PC	(3)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

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FORM JUN 78 133 PREVIOUS EDITION OBSOLETE

SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

TO 1T-38A-06, Unit Code Manual
TO 1T-38A-2-4, Operation and Maintenance
TO 1T-38A-4-4, Illustrated Parts Breakdown
AFTO Form 26
AFTO Form 349

Training Equipment

Available Aircraft (4)
CTK (1)
Ear Protection (1)

Training Methods

Performance (16 hrs)

Instructional Guidance

The lab instructor will supervise the lab period, continually administer, evaluate, and critique progress checks as each student progresses, ensure student has correct module materials and equipment, record student progress, counsel student as needed regarding academic and nonacademic reasons, monitor breaks and clean-up periods, ensure student complies with safety practices IAW applicable AFOSH standards. The instructor will provide individual assistance to each student as needed during the lab period. Each student must satisfactorily complete the individual performance exercise and/or progress check to satisfy the objectives. The instructor will pick up all reusable training literature from the student as feasible. Turn off all power when applicable to conserve energy and resources. An instructor assist is defined as limited aid, such as technical direction or explanation and/or technical order interpretation given a student who can proceed no further on his/her own. A detected safety violation is an automatic failure for that objective. Ensure students wear ear protectors in high intensity noise areas. The instructor will refer to Part II Teaching Guide for detailed instructions on this module.

PLAN OF INSTRUCTION/LESSON PLAN PART I

NAME OF INSTRUCTOR	COURSE TITLE
	Aircraft Environmental Systems Mechanic

BLOCK TITLE
Utility Systems and Flight-Line Maintenance

1. COURSE CONTENT	2. TIME
11. Flightline Maintenance, Removal and Replacement System Components	24
*a. Using assigned aircraft, applicable TOs, TO exceptions, CTK, MDC forms, and working in a group of not more than two students, remove and replace a minimum of two components of the bleed air distribution system. A maximum of three instructor assists, per component, is allowed. Apply safety precautions without error. STS: 15e, 15f Meas: PC	(4)
*b. Using assigned aircraft, applicable TOs, TO exceptions, CTK, MDC forms, and working in a group of not more than two students, remove and replace a minimum of two components in the air conditioning system. A maximum of three instructor assists, per component, is allowed. Apply safety precautions without error. STS: 16e, 16f Meas: PC	(6)
*c. Using assigned aircraft, applicable TOs, TO exceptions, CTK, MDC forms, and working in a group of not more than two students, remove and replace a minimum of two components in the auxiliary air system. A maximum of three instructor assists, per component, is allowed. Apply safety precautions without error. STS: 17e, 17f Meas: PC	(4)
*d. Using assigned aircraft, applicable TOs, TO exceptions, CTK, MDC forms, and working in a group of not more than two students, remove and replace a minimum of two components in the pressurization system. A maximum of three instructor assists, per component, is allowed. Apply safety precautions without error. STS: 18e, 18f Meas: PC	(4)
*e. Using assigned aircraft, applicable TOs, TO exceptions, CTK, MDC forms, and working in a group of not more than two students, remove and replace a minimum of two components in the oxygen system. A maximum of three instructor assists, per component, is allowed. Apply safety precautions without error. STS: 20e, 20f Meas: PC	(5)
*f. Using assigned aircraft, headset, source of air and electrical power, checklist, and working in a group of not more than two students, perform an operational check of the bleed air distribution, air conditioning, and auxiliary air systems. A maximum of three instructor assists is allowed. Apply safety precautions without error. STS: 15c, 16c, 17c Meas: PC	(1)

SUPERVISOR APPROVAL OF LESSON PLAN

SIGNATURE AND DATE	SIGNATURE AND DATE

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SUPPORT MATERIALS AND GUIDANCE

Student Instructional Materials

TO 1T-38A-06
TO 1T-38A-2-4
TO 1T-38A-4-4
AFTO Form 349
AFTO Form 350, Repairable Item Processing Tag
AFTO Form 781A, Maintenance Discrepancy Work Document
AF Form 2413

Training Equipment

Available Aircraft (7)
Toolkit (1)
Ear Protectors (1)

Training Methods

Performance (24 hrs)

Instructional Guidance

The lab instructor will supervise the lab period, continually administer, evaluate, and critique performance exercises and progress checks as each student progresses, ensure student has correct module materials and equipment, record student's progress, counsel student as needed regarding academic and nonacademic reasons, monitor breaks and clean-up periods, ensure student complies with safety practices IAW applicable AFOSH standards. The instructor will provide assistance to each student as needed during the lab period. Each student must satisfactorily complete the individual performance exercise and/or progress check to satisfy the objectives. An instructor assist is defined as limited aid such technical direction or explanation and/or technical order interpretation given a student who can proceed no further on his/her own. The instructor will pick up all reusable training literature from the student as feasible. Turn off all power when applicable to conserve energy and resources. A detected safety violation is an automatic failure for that objective. Ensure students wear ear protectors in high intensity noise level area. The instructor will refer to Part II Teaching Guide for detailed instructions on this module.

12.	Military Training	13
	a. Physical Conditioning	(6)
	b. Commander's Call	(1)
	c. Predeparture Safety Briefing and End-of-Course Appointments	(6)
13.	Written Test and Critique	1.5
14.	Course Critique and Graduation	.5

PROGRAMMED TEXT
C3ABR42334-PT-105
C3ABR42331-PT-303

Technical Training

Aircraft Pneudraulic Systems Mechanic
Aircraft Environmental Systems Mechanic

MAINTENANCE TOOLS

12 April 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

Air Force 20 May 81-600 *1860

RGL: 9.2

OBJECTIVES

The following objective pertains to the Aircraft Pneudraulic System Mechanic Course. Students enrolled in the C3ABR42334 course will only accomplish the following objective:

1. Using a handtool display, match the numbered tools with a list of selected statements that pertain to tool selection, care, and use. A minimum of 24 out of 30 tools must be matched correctly.

The following objective pertains to the Aircraft Environmental System Mechanic Course. Students enrolled in the C3ABR42331 course will only accomplish the following objective:

1. Relate maintenance tools to their proper uses with 80% accuracy.

INSTRUCTIONS

This text is presented in small steps called frames. After each frame you will select correct statements, match names, and/or numbers to the description and/or use of maintenance tools. Compare your answer with the correct one found at the bottom of the following frame. If your answer is correct, go to the next frame. If your answer is wrong, read the frame again and see how the correct response was derived. READ CAREFULLY AND DO NOT HURRY!

This text is divided into six sections:

Section I	Page 3	Frames 1 through 14
Section II	Page 20	Frames 15 through 30
Section III	Page 40	Frames 31 through 40
Section IV	Page 52	Frames 41 through 63
Section V	Page 83	Frames 64 through 84
Section VI	Page 105	Frame 85

Turn to Frame 1 and begin.

Supersedes 3ABR42334-PT-105, 3ABR42331-PT-303, 19 December 1980, which may be used until present stocks are exhausted.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

Frame 1

When we mention tools we may think of several general types and uses for tools. This is why several tools will be found in your tool box. Each is designed for a special purpose. The tools included in most toolkits are described in this text.

Handtools are the mechanic's best friend, he is helpless without them. Regardless of the type of job a mechanic is assigned, he must choose the right tool and be sure to use it correctly. Without a thorough knowledge of the right way to use tools, the mechanic wastes time, cuts down his efficiency, and may injure himself. Mechanic's tools are designed very carefully to do a job. Tools must be used properly if they are to be as effective as the manufacturer intended. Many people think that tools can stand all kinds of punishment. Any mechanic who has this opinion is inviting a lot of grief and possible injury.

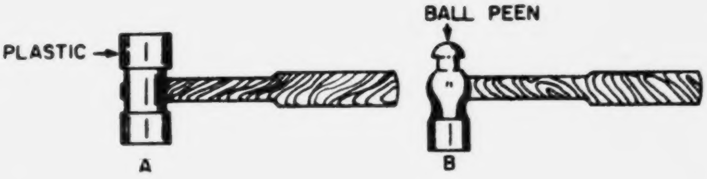
When using maintenance tools, exercise extreme caution to insure the security of the maintenance tools. Leaving your tools unattended and your toolkit unlocked makes you an easy target for someone to pick them up mistakenly or steal them. Remember that you are responsible for the maintenance tools you use. When you are not using the handtool, put it in the toolkit and keep the toolkit with you or store it in the appropriate secure area.

//////////No Response Required//////////

Frame 2

Hammers are tools used to strike, drive, pound, etc. Hammers are made up of a head and a handle. The head is made up of one or more faces which may be round, square, or rectangular and concave, flat or convex. The head has a hole which is usually oval-shaped and bell-mouthed at each end. The shape of the eye makes it easy to put in and clamp the handle to the head.

Each hammer has its own special use. The good mechanic learns to select the correct hammer for the particular work at hand.



Match the hammers above to the nomenclatures below:

_____ 1. Hammer, hand, machinist, ball peen, 1 lb.

_____ 2. Hammer, hand, face diameter 1 1/2 inch, screw-in inserted face, plastic, 1 1/4 lb.

Hammers are generally classified as "hard face" hammers and "soft face" hammers. Hard face hammers are made of steel. Soft face hammers have a face made of material softer than steel, for example: lead, plastic, rubber, wood or brass.

Hammers are further classified according to the weight of the head (without the handle) and they range from four ounces to 20 pounds in size.

Answer each of the following statements as either true (T) or false (F).

____ 1. Hammer size is determined by the weight of the hammer head.

____ 2. Soft face hammers are made of steel.

____ 3. Hard face hammers are made of such materials as lead, plastic or rubber.

Answers to Frame 2: 1. b 2. a

Frame 4

One of the better known hard face hammers is the ball peen hammer. The name of this hammer came from the ball-shaped end which is used to peen (expand or stretch) metal. The ball-peen hammer is frequently used to expand the end of a rivet in a hole or for forming gaskets. The flat-faced end of the hammer is used for tapping a punch or a chisel or for other rough work.

Ball-peen hammers come in different sizes (weight). The size of these hammers is given in weight of the head in ounces. The most commonly used hammer is a 12-ounce hammer. Although six to eight ounce hammers, for light work, and 16 to 32 ounce hammers, for heavy work, are available. The type of work that you do should determine which weight hammer you will use.

Check (✓) the true statements below.

_____ 1. The flat-faced end of the ball-peen hammer is used when riveting.

_____ 2. Ball-peen hammers are used where steel hammers may mar the work.

_____ 3. The weight of the head determines the size of the hammer.

Answers to Frame 3: 1. T 2. F 3. F

Frame 5

Soft-faced hammers are used to form soft metals or to drive close-fitting parts together. The soft material on the face of these hammers can be damaged easily. Therefore, soft-faced hammers should not be used for rough work such as driving a punch, nails or bolts.

Mallets are also available in your shop. The only difference in a mallet and a soft-faced hammer is that the entire head of a mallet is made up of rubber, brass, or plastic. However, only the face of a soft-faced hammer is made up of these materials.

1. Match each of the hammers in column B with the proper use in column A.

Column A	Column B
1. _____ Used for forming gaskets and other light work.	a. Mallet
2. _____ The entire head is composed of rawhide to prevent injury.	b. Ball-peen hammer
3. _____ Brass-faced hammer used where steel hammer may mar the work.	c. Soft-faced hammer

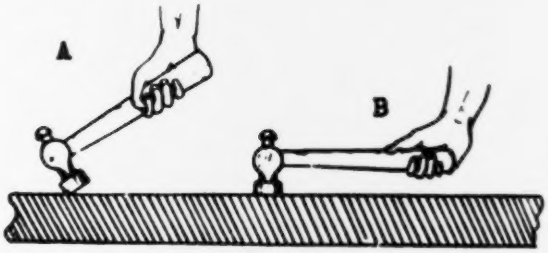
Answers to Frame 4: 1. _____ 2. _____ 3. ✓

Frame 6

Practice is the only way that you will learn to use a hammer properly. However, the correct grip is an aid to a hammer's right use.

The handle should be held near the end with the fingers underneath and the thumb along the top or side. The thumb should always rest on the handle itself, never on top of the fingers. The grip should be tight enough to control the blow. The blow is delivered so the face of the hammer is parallel to the work being struck.

A blow off the side of the object being struck is usually caused by grease or oil on the face of the head. Should this happen, the face should be wiped off with a rag and then rubbed briskly with coarse sandpaper or emery cloth.



1. Study the illustration above, then answer the questions below.

   a. The correct way to hold and deliver a blow with a hammer is shown by drawing ____.

2. Check (✓) the true statements below.

____ a. While using a hammer, always hold it near the end of the handle.

____ b. When delivering a blow with a hammer, the thumb must rest on top of the fingers.

____ c. The face of the hammer must squarely meet the object being struck.

Answers to Frame 5: 1. b 2. a 3. c

Probably most accidents with hammers are caused by loose hammer heads, sweaty hands, or oily or greasy handles. The user should pay close attention to these dangers when using a hammer.

Never use a hammer with a loose head or a cracked handle, as this is dangerous to both the material being worked on and to other personnel. A loose head can be tightened by driving the wedge, found in the end of the handle, in, flush with the head. If the head starts to work off the end of the handle, it can be set back in the proper position by striking the butt end of the handle against a solid object. After the head has been moved back to its correct position, it should be tightened by driving the wedge into the handle in the eye of the head. If any defects are noticed, it should be repaired or turned in for a serviceable hammer.

Check (✓) the true statements below.

____ 1. A cracked hammer handle should be glued or taped before using.

____ 2. If you can't repair a hammer, you should turn it in for a serviceable one.

____ 3. A loose hammer head can be set back by striking the butt end of the handle against a solid object.

Answers to Frame 6: 1. a. B

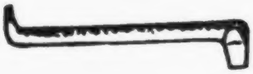
2. a. ✓ b. ___ c. ✓

Frame 8

Screwdrivers are grouped by the types of points they have. The screwdrivers points are: common, crosspoint, and clutchhead. Study the illustrations below, of the four screwdrivers, and read their description.

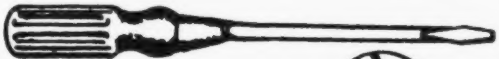
The offset screwdriver has a sharp bend at each end. It has flat tips or crosspoints.

Ⓐ



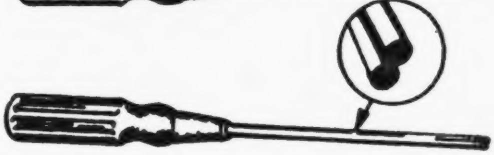
You should be familiar with the common screwdriver - it has a flat tip.

Ⓑ



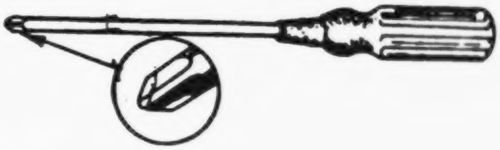
The clutchhead screwdriver stands alone in that it does not look like any other type.

Ⓒ



The crosspoint screwdriver family includes both the Phillips, and the Reed & Prince types.

Ⓓ



Match the items shown above with the nomenclature below:

____ 1. Screwdriver, flat tip, 3/8-inch wide tip, 6-inch long blade.

____ 2. Screwdriver, crosspoint, 6-inch long blade.

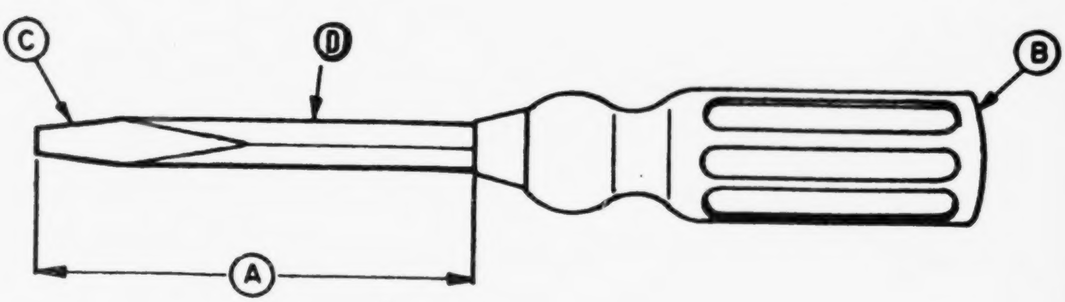
____ 3. Screwdriver, flat tip, offset, 4 1/2-inch long.

____ 4. Screwdriver, clutchhead, 6-inch long blade.

Answers to Frame 7: 1. ____ 2. _✓_ 3. _✓_

A common screwdriver is sometimes called a flat tip screwdriver. This is because the working edge of the blade is ground flat and straight and not a sharp edge like a knife or chisel blade. The common screwdriver, shown below, has a steel shank set in a handle of wood or plastic.

The size of all screwdrivers is the combined length (in inches) of the blade and shank. Can you name the parts of the drawing below? Part D is the shank. It is steel and usually round in shape. However, some heavy duty screwdrivers may have a square shank. Part C of the illustration is the blade. The blade is the working part of the screwdriver. The blade is ground flat and straight for the best possible contact. Part B of the illustration is the handle which is made of wood, plastic, or other nonconductor of electricity.



1. Match the items lettered in the drawing above with the statements listed below:

____ 1. Shank

____ 2. Handle

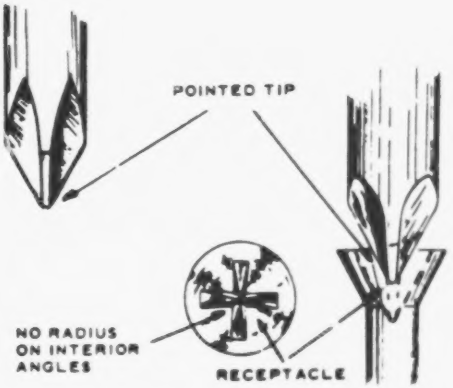
____ 3. Blade

____ 4. Dimension used to determine the specified length of a screwdriver.

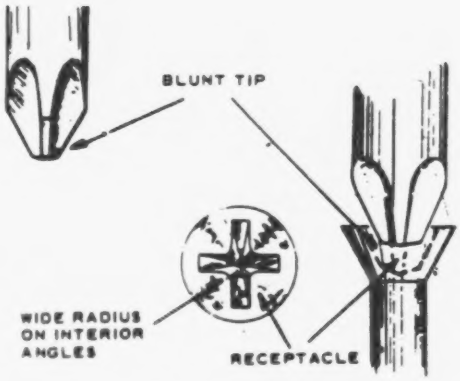
Answers to Frame 8: 1. B 2. D 3. A 4. C

Frame 10

The crosspoint screwdrivers, shown in the illustration below, are made to fit a specific screw or bolt. The Reed and Prince crosspoint tip should be used only on a Reed and Prince screw. The Phillips screwdriver is designed for use with only a Phillips screw. Look at the difference in the shapes of the points and flutes (rounded grooves). Use of the wrong size or type of crosspoint screwdriver will result in damaged screwheads and unnecessary loss of man-hours in replacing them.



A REED & PRINCE TYPE



B. PHILLIPS TYPE

Mark the following statements true (T) or false (F).

_____ 1. When removing an AGE unit inspection plate, it is best to observe the exact fit of the crosspoint screwdriver and change to the correct type as required.

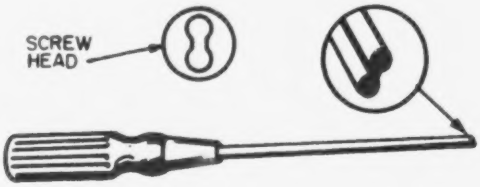
_____ 2. The Reed and Prince screwdriver has a sharper point than the Phillips type.

_____ 3. The size of the screwdriver is determined by the length of the shank and blade.

_____ 4. The phillips screwdriver can be used on a Reed and Prince screwhead.

Answers to Frame 9: 1. 1. D 2. B 3. C 4. A

Some equipment, especially assembly line made goods, use clutchhead screws. Their design is similar to a figure eight (see illustration). This type of screwhead is used because the screw can be easily put in with power tools and not strip the screwhead. A clutchhead screwdriver must be used to put in or take out clutchhead screws. Otherwise, damage to the screwhead will occur.



1. Check (✓) the true statements below.

_____ 1. If the shank of a clutchhead screwdriver is ten inches long and its handle is four inches long, it is a ten inch screwdriver.

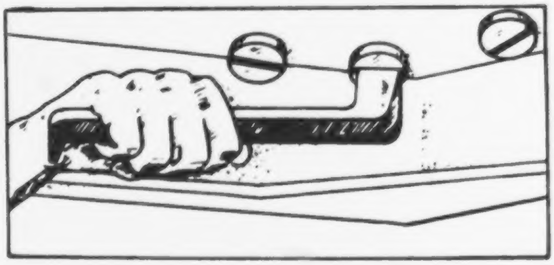
_____ 2. The clutchhead screwdriver has a sharply pointed tip.

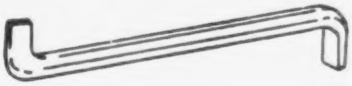
_____ 3. The clutchhead screwdriver tip resembles a figure eight.

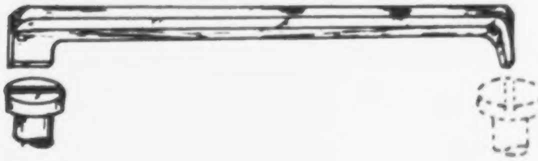
Answers to Frame 10: 1. T 2. T 3. T 4. F

Frame 12

The offset screwdriver is used to put in, take out, or adjust screws which cannot be reached by other screwdrivers. (See illustration below). Offset screwdrivers come with a crosspoint for Reed and Prince and Phillips screwheads or flat tips for common and slotted screwheads. Each end of the flat tip offset screwdriver has a blade bent at a right angle (90 degree) to the shank. The working edge of one blade is parallel to the shank; the other is set at a 90 degree angle to the shank. By alternating the use of the blades, a screw can be tightened or loosened with very little movement. This feature makes this tool indispensable in tight corners where other types of screwdrivers will not enter.







1. Check (✓) the true statements below.

_____ 1. An offset screwdriver has a tip like any other screwdriver, except that it has a sharp bend at each end.

_____ 2. The two tips on an offset screwdriver are for use on different sized screwheads.

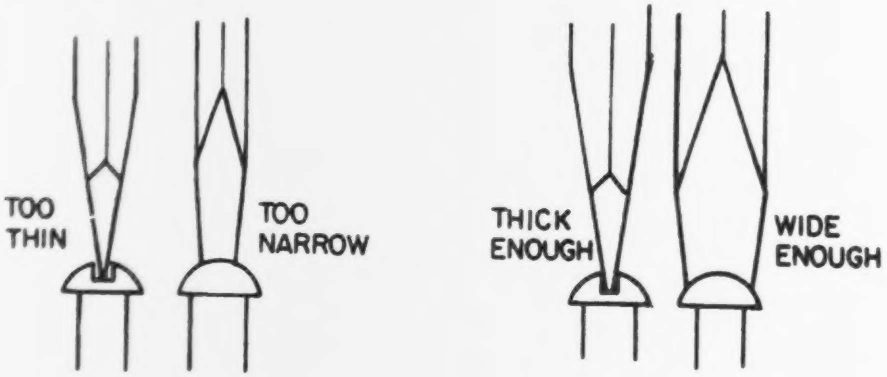
_____ 3. An offset screwdriver may be used in a limited access area where a longer screwdriver cannot be used.

Answers to Frame 11: 1. _✓_ 2. ____ 3. _✓_

Frame 13

Screwdrivers should only be used to put in or take out screws. They are not designed nor intended to be used as a chisel, a punch, a pry, a nail puller, or a hammer. While being used for its intended purpose, sufficient pressure should be put on to stop it from climbing out of the slot. Most accidents with screwdrivers are caused by the blade slipping out of the screw slot. All users should exercise caution to prevent slipping. They should also avoid holding any part of their body where a slipping screwdriver could cause injury. Never use a screwdriver to check electrical circuits.

When you select a screwdriver, select the largest one whose blade will make a good fit in the screw slot. This will prevent burring of the slot and damage to the blade. It will also reduce the force required to hold the blade in the slot.



Check (✓) the correct statements below.

_____ 1. An important factor to consider when selecting a screwdriver for a particular screw is the size of the blade.

_____ 2. Damage to screwheads and screwdrivers is reduced when the proper size screwdriver is used.

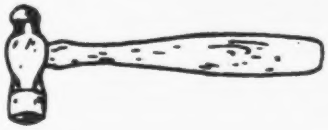
_____ 3. It is important that the correct amount of pressure be applied to the screwdriver when installing or removing screws.

_____ 4. A screwdriver should never be used as a chisel, punch, prybar or nail puller.

Answers to Frame 12: 1. 1. ✓ 2. ____ 3. ✓

Frame 14

Test your knowledge of the previous frames by answering the following questions. If you miss any, go back and review the appropriate frame.



1. This handtool is called a

   a. mallet.

   b. sledge hammer.

   c. ball peen hammer.

   d. plastic hammer.

2. Hammer size is determined by the

   a. length of the handle.

   b. diameter of the face.

   c. weight of the hammer head.

   d. weight of the hammer head and handle combined.

3. Soft face hammers have a face made of

   a. lead.

   b. brass.

   c. plastic.

   d. any of the above.

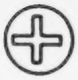
4. When delivering a blow with a hammer, hold the hammer

   a. with your thumb resting on top of the fingers.

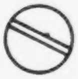
   b. near the end of the handle.

   c. so the face will strike the object at an angle.

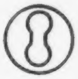
   d. wherever it feels most comfortable to the user.



5. What type of screwdriver is used for the above screwhead?
   - a. Offset flat tip screwdriver.
   - b. Crosspoint screwdriver.
   - c. Common screwdriver.
   - d. Clutchhead screwdriver.



6. What type of screwdriver is used for the above screwhead?
   - a. Offset crosspoint screwdriver.
   - b. Crosspoint screwdriver.
   - c. Common screwdriver.
   - d. Clutchhead screwdriver.



7. What type of screwdriver is used for the above screwhead?
   - a. Offset flat tip screwdriver.
   - b. Crosspoint screwdriver.
   - c. Common screwdriver.
   - d. Clutchhead screwdriver.

8. What type of screwdriver is best used in tight quarters?
   - a. Offset screwdriver.
   - b. Crosspoint screwdriver.
   - c. Common screwdriver.
   - d. Clutchhead screwdriver.

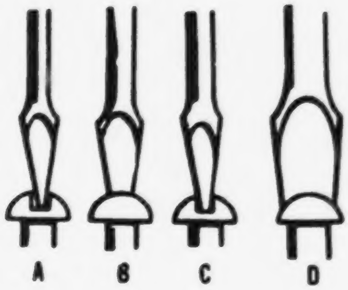
9. The size of a screwdriver is determined by the

   a. size of the blade.

   b. size of the handle.

   c. length of the screwdriver.

   d. combined length of the blade and the shank.



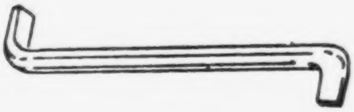
10. Which of the above illustrations shows the correct size of screwdrivers to use?

    a. B and C

    b. A and D

    c. A and B

    d. C and D



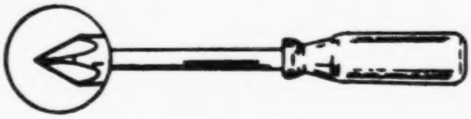
11. What tool is pictured above?

    a. Flat tip screwdriver.

    b. Crosstip screwdriver.

    c. Crosstip offset screwdriver.

    d. Offset flat tip screwdriver.



12. What tool is pictured above?

    a. Crosstip (Phillips) screwdriver.

    b. Crosstip (Reed and Prince) screwdriver.

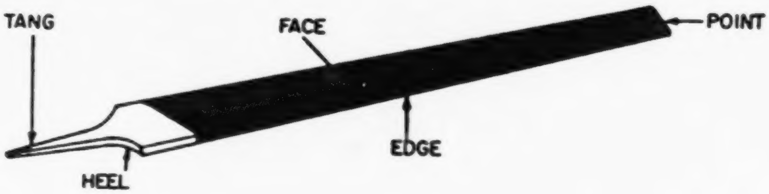
    c. Crosstip offset screwdriver.

    d. Common screwdriver.

Answers to Frame 13: 1. ✓ 2. ✓ 3. ✓ 4. ✓

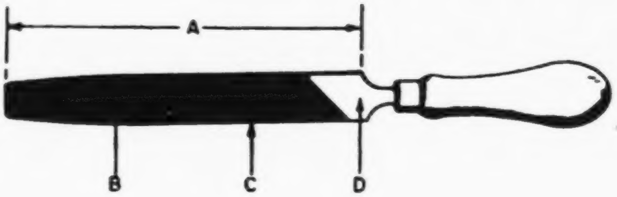
Frame 15

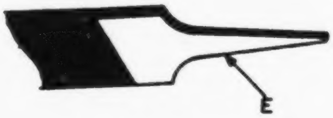
A file is a precisely made tool of hardened steel. You use it to cuff, smooth, or remove small parts of metal. Files have a cutting edge across the face. Some files have a cutting edge on both the face and the edge. The names of the parts of a file are shown in the drawing below.



File size is its length, in inches, from the point to the heel. NOTE: Never use a file without a handle as the tang could be driven into your hand.

Match the lettered items in the drawings with the statements below.





___ 1. File length

___ 2. File tang

___ 3. File edge

___ 4. File face

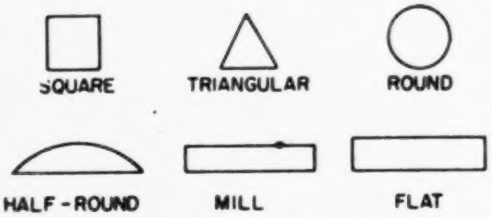
___ 5. File heel

Answers to Frame 14:

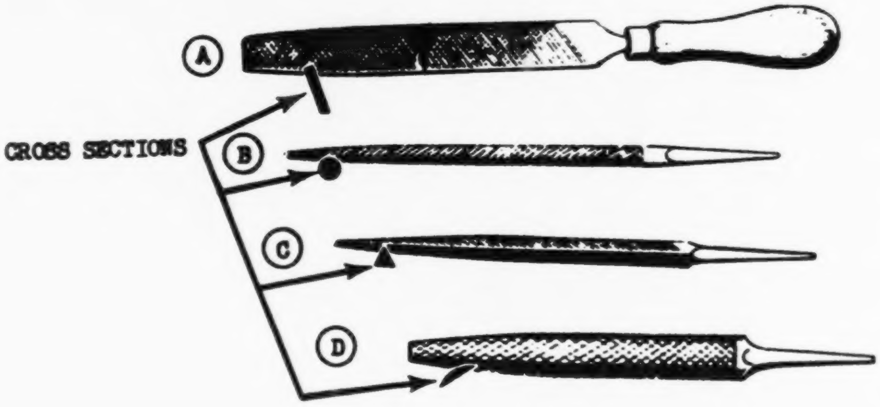
Question No	Answer	Review Frame	Question No	Answer	Review Frame
1.	c	2	7.	d	11
2.	c	4	8.	a	12
3.	d	3	9.	d	9
4.	b	6	10.	d	13
5.	b	10	11.	d	12
6.	c	9	12.	b	10

Frame 16

Files come in a number of shapes so that you will have a tool for every job. Some cross-section views of file shapes are shown in the illustration below.



Files of different shapes are given specific names. Each file is also designed for a specific purpose. A flat file (illustration A) is used to file a flat surface or edge. A round file (illustration B) sometimes known as a rattail file, is used to enlarge a round hole. A taper file (illustration C) is used for various filing operations such as sharpening saw blades or filing small parts. A half-round (illustration D) may be used on a flat or concave (hollow and curved) surface or edge.



1. Match the items illustrated above with the nomenclature given below.

_____ 1. File, hand, round, 8-inch (rattail file).

_____ 2. File, hand, half-round, 8-inch.

_____ 3. File, hand, flat, 10-inch.

_____ 4. File, hand, taper, 8-inch.

Frame 16 Continued

2. Check (✓) the true statements below.

_____ 1. You should use a taper file for enlarging a round hole.

_____ 2. A half-round file should be used for filing a concave hole.

_____ 3. Use a flat file for removing a small amount of metal on a straight flat edge.

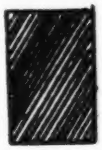
_____ 4. The tang is the file handle.

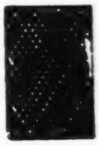
Answers to Frame 15: 1. A 2. E 3. C 4. B 5. D

Frame 17

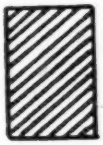
The cut of a file refers to both kind and coarseness of the teeth. The kind of teeth refers to how the cutting teeth are aligned. Files have either single-cut or double-cut teeth. Single-cut files have rows of teeth cut parallel to each other.

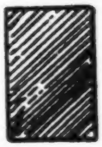
Double-cut files have criss-cross rows of teeth. The single-cut files are for fine, detailed work. The double-cut files are used for quick removal of metal and for rough work.


Single-Cut


Double-Cut

The coarseness of cut for a file is determined by the spacing (distance between the teeth) and size of the teeth. Three classes of file coarseness are shown in the drawings below.


Bastard


Second Cut

Smooth

Match the cut of a file in column B to the proper description listed in column A by placing the letter in the space provided.

		Column A		Column B
____	1.	Rows of teeth parallel to each other	a.	double-cut file
			b.	smooth grade file
____	2.	Rows of teeth that criss-cross each other	c.	single-cut file
____	3.	A file with teeth cut deep and far apart	d.	bastard grade file
			e.	rasp-cut file
____	4.	A file with teeth cut shallow and close together.		

Answers to Frame 16: 1. 1._B_ 2._D_ 3._A_ 4._C_ 2. 1.__ 2._✓_
3._✓_ 4.___

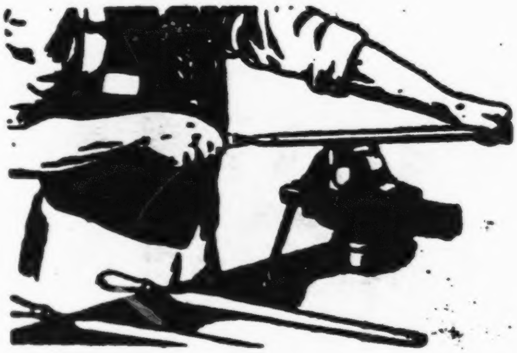
Frame 18

The file picked for any kind of job depends on the material being worked and the finish desired. For soft materials use a coarse file. For hard materials use a fine file. For a very accurate finish use a very smooth file. For rough work use a coarse file.

A file should never be used without a handle. Without a handle it is not only hard to control but it is also likely to pierce your hand. The handle should be tight on the tang of the file.

The handle of a file should be held (by a right handed person) in the right hand with the fingers underneath and the thumb on top. The left hand should grip the point of the file between the palm and fingers. This will give you the greatest control of the file. For very accurate finishes, the thumb and fingers of the left hand should rest on top of or lightly grip the point of the file. This is shown in the illustration.

40



A file should never be used on a material harder than itself, or on scaly materials. This will break the teeth and make the file useless.

Mark the following statements true (T) or false (F).

____ 1. A right handed filer should hold the handle of the file in his right hand with the fingers on the top and the thumb on the heel.

____ 2. For accurate finishes, the thumb and fingers of the left hand should rest on top of the file or lightly grip the point of the file.

____ 3. A left handed filer should hold the handle of the file in his left hand with his fingers underneath and the thumb on top of the handle.

Answers to Frame 17: 1. C 2. A 3. D 4. B

Frame 19

The way you use a file varies with the work to be done and the type of file to be used. However, the general procedure is as follows: Use a smooth, firm forward stroke to "cut" the material being filed. Use only enough pressure to keep the file cutting. DO NOT drag the file during the return stroke or the teeth may be dulled.

Not enough pressure on the forward stroke will cause the file teeth to slip over the work, resulting in dulled file teeth. Too much pressure will overload the file teeth, causing the cut to be irregular.

1. Answer each of the following statements as true (T) or false (F).

____ 1. The procedure for using a file is the same for every job.

____ 2. The teeth of a file can be dulled if the file is used improperly.

____ 3. The procedure for using a file is not the same for every job.

____ 4. In order for the file to cut the material, a lot of pressure must be applied.

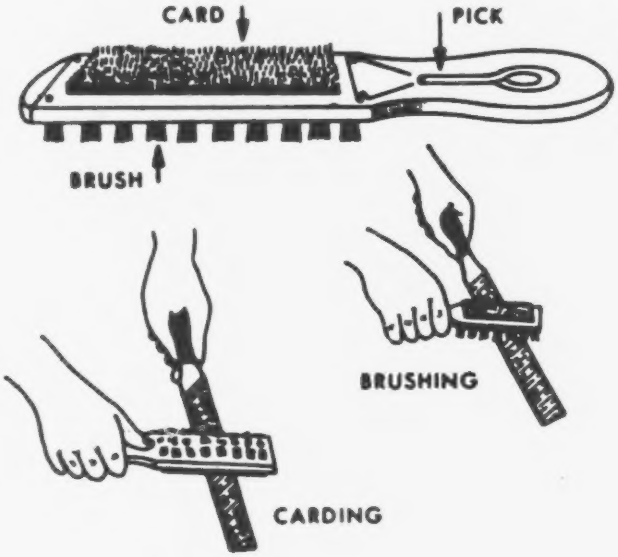
2. Match the improper use of a file (column A) to the condition it will cause (column B).

		Column A		Column B
____	1.	Insufficient pressure	a.	irregular cut
____	2.	Excessive pressure	b.	dulled teeth
			c.	broken file

Answers to Frame 18: 1. F 2. T 3. T

Frame 20

When you use a file you will get small chips or filings. Filings often wedge between the file teeth and reduce the cutting action. Clean a file by brushing it with a wire brush, called a file card (see figure below). Push the file card in a direction parallel with the file teeth. The reverse side of the file card contains a fiber brush. It is used for brushing the file after carding. A metal pick may be removed from the handle of the file card. The pick aids in removing metal filings that cannot be removed otherwise. After cleaning a file it should be wrapped in cloth or paper and placed in your toolkit. Wrapping protects the teeth.



1. Check (✓) the true statements below.

_____ 1. To clean a file, use the card before the fiber brush.

_____ 2. Files should be cleaned and wrapped after use.

Answers to Frame 19: 1. 1. F 2. T 3. T 4. F
2. 1. B 2. A

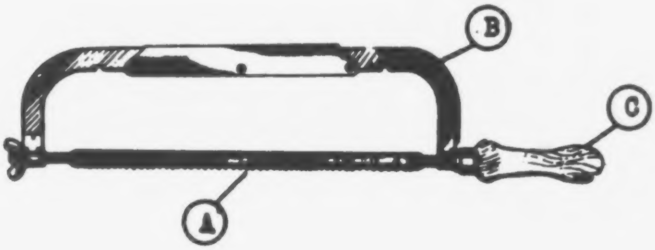
Hacksaws, used for cutting metal, have either adjustable frames or solid frames. Adjustable frames can be changed to hold blades from eight to sixteen inches in length. Solid frames, although more rigid, will take only the blade length for which they are made. The length is the distance between the two pins which hold the blade in place. These pins can be adjusted within the frame to hold the blade parallel to or at right angles to the frame. To make a cut deeper than the frame will permit, the blade is turned sideways (at right angles to the frame). All frames, either solid or adjustable, have adjustment screws for drawing the blade tight.

1. Match the items lettered in the drawing on the right with the parts of the hacksaw as listed on the left.

____ 1. Frame

____ 2. Handle

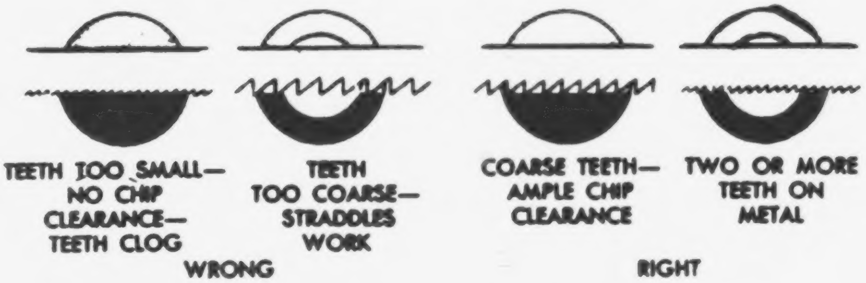
____ 3. Blade



Answers to Frame 20: 1. 1. ✓ 2. ✓

Frame 22

The drawings below show the way to pick saw blades that are the most suitable for a job. Study the drawings carefully and then answer each of the following statements as being either true (T) or false (F).


TEETH TOO SMALL— NO CHIP CLEARANCE— TEETH CLOG
TEETH TOO COARSE— STRADDLES WORK
COARSE TEETH— AMPLE CHIP CLEARANCE
TWO OR MORE TEETH ON METAL
WRONG
RIGHT

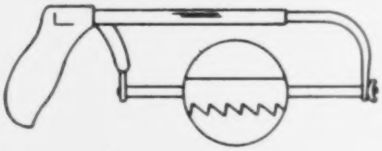
____ 1. Hacksaw blades are available with different numbers of teeth per inch.

____ 2. When cutting thin materials with a hacksaw a large toothed hacksaw blade should be used.

____ 3. When cutting large stock with a hacksaw a small toothed hacksaw blade should be used.

Answers to Frame 21: 1. 1. B 2. C 3. A

The drawing below shows the right way to mount a blade in the frame.



When you use the hacksaw, always apply pressure on the forward stroke. This is necessary because the cutting teeth of the hacksaw blade point forward. The teeth do not cut on the back stroke; thus you should not apply pressure on the back stroke.

Answer each of the following statements as either true (T) or false (F).

____ 1. When using a hacksaw, pressure is applied to the saw on the forward stroke only.

____ 2. Hacksaw blades are replaceable.

____ 3. Some hacksaw frames are adjustable for different blade lengths.

____ 4. Hacksaw blades are installed in the frame with the teeth pointing backward (toward the handle).

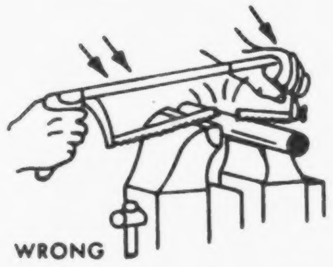
Answers to Frame 22: 1. T 2. F 3. F

Frame 24

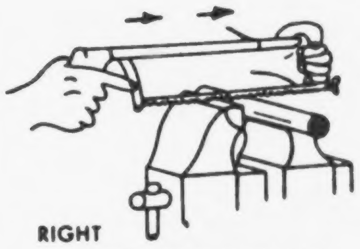
The use of a hacksaw is much like the use of a file. The work should be held rigid. The cutting stroke should be as long as possible. There should not be over 60 strokes per minute. Pressure should be applied on the forward stroke only.

The blade should be kept straight and in line with the cut, otherwise the blade may be cramped and broken. When the work is nearly cut through, the pressure on the saw should be taken off. This stops the teeth from catching. Special care is needed toward the end of a cut through thin material. When cutting very thin stock, it is wise to clamp the work between two pieces of wood and saw through all three pieces. This prevents chattering and possible damage to the work.

The chief danger when using the hacksaws is injury to the hand, should the blade break, and they do break. The blade will break if the user bears down too hard on the cut or does not push the saw in a straight line. If the work is not held tight in a vise it may slip, twisting the blade enough to break it.



TOO GREAT FORCE BREAKS BLADE



CORRECT FORCE BLADE CUTS ON FORE STROKE ONLY

Check (✓) the true statements below.

____ 1. The cutting stroke should be as short as possible.

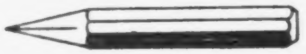
____ 2. Most of the force you exert on a hacksaw should be downward.

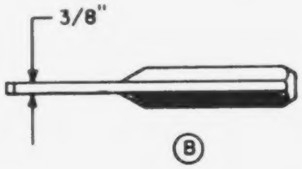
____ 3. The greatest danger, when using a hacksaw, is when the blade breaks.

Answers to Frame 23: 1. T 2. T 3. T 4. F

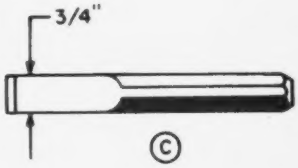
Frame 25

The cold chisel gets its name from the fact that it can be used to cut "cold" metal (without first softening the metal by heating). Chisels are made in a variety of shapes, suited for different types of work. The figure below shows three types of chisels.


Ⓐ



Ⓑ



Ⓒ

1. Match the item below with the correct nomenclature.

____ 1. Chisel, cold, hand, 3/4-inch wide cut, 7 inches long.

____ 2. Chisel, cape, hand, 3/8-inch wide cut.

____ 3. Chisel, diamond point, hand.

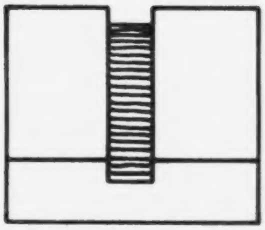
Answers to Frame 24: 1.___ 2.___ 3.✓

Frame 26

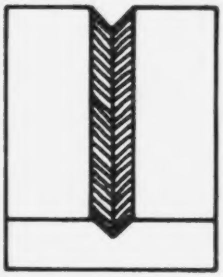
Match each chisel in Column B with the correct use in Column A.

Column A

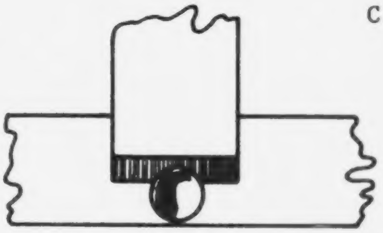
____ 1. To cut narrow grooves in metal.



____ 2. To cut "V" grooves in metal.

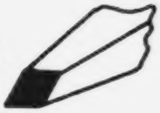


____ 3. To cut the heads off rivets.

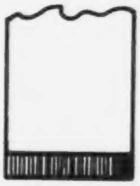


Column B

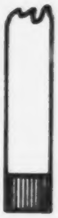
A Diamond point chisel.



B Flat chisel. (cold)



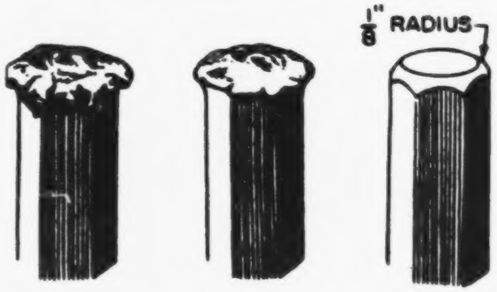
C Cape chisel.



Answers to Frame 25: 1. 1. C 2. B 3. A

Hammering on a chisel may cause its head to be mushroomed (see figure below). A chisel in this shape should not be used. The bent-over edges may break off and hurt you.

The chisel at the left is badly mushroomed. The one in the center is slightly mushroomed. Both chisels should be dressed until they are in the condition shown at the right.



1. Answer the following statement as being either true (T) or false (F).

____ 1. A chisel with a mushroomed head should be dressed on a grinding wheel to remove all cracks and rolled over edges.

2. Match each chisel in column B with the correct use in column A.

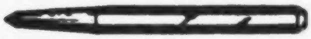
	Column A	Column B
____ 1.	Used to cut off rivet heads, cut sheet metal, and to split nuts.	a. Flat chisel
____ 2.	Used for cutting narrow grooves in metal.	b. Cape chisel
____ 3.	Used for cutting "V" grooves and squaring corners in metal.	c. Diamond point chisel

Answers to Frame 26: 1. C 2. A 3. B

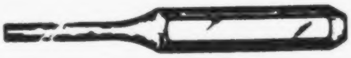
Frame 28

Punches are made of the same material and need the same care as do cold chisels. The work for which they are best suited depends on their shape. The illustrations and descriptions show three types of punches.

The center punch has a sharp "pointed" end.	The pin punch has a straight point.	The drift punch has a tapered point.



Ⓐ



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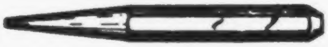


Ⓒ

1. Match the items illustrated above with the nomenclature listed below:

____ 1. Punch, center, solid, 3/8-inch diameter.

____ 2. Punch, drive pin, straight point, 1 1/2-inch long, 5/32-inch diameter.

____ 3. Punch, drift, taper 1 1/2-inch long.

Answers to Frame 27: 1. 1. T

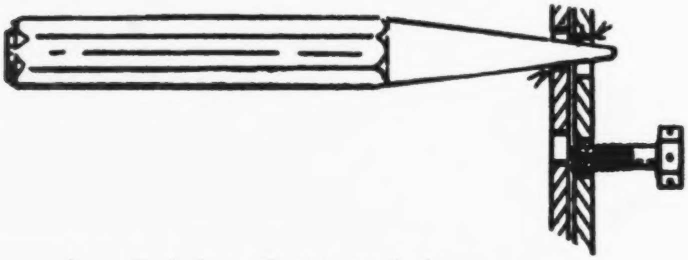
2. 1. A 2. B 3. C

Frame 29

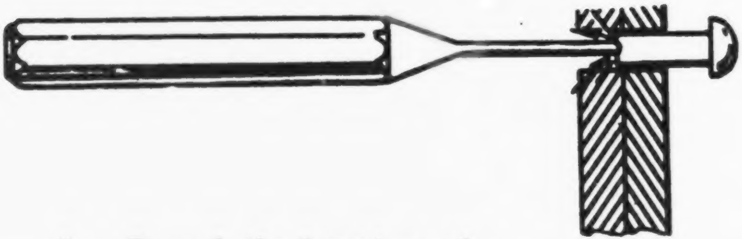
1. Match each punch listed in Column B with the correct use shown in Column A.

Column A

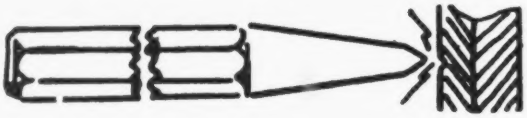
_____1. **Aligning parts for assembly.**



_____2. **Driving rivets or bolts out of holes.**



_____3. **To mark the locations of holes to be drilled.**



Column B

Ⓐ **Pin punch.**

Ⓑ **Drift punch.**

Ⓒ **Center punch.**

Frame 29 Continued

2. Match each tool in column B with the proper use in column A.

Column A

____ 1. For driving bolts or rivets out of holes.

____ 2. For marking the location of holes to be drilled in metal.

____ 3. To align bolt holes of parts for assembly.

____ 4. For cutting "V" grooves in metal.

____ 5. For cutting narrow grooves in metal.

____ 6. For cutting the heads off rivets and for splitting nuts.

Column B

A. Pin punch

B. Flat chisel

C. Drift punch

D. Diamond point chisel

E. Center punch

F. Cape chisel
F. Cape chisel

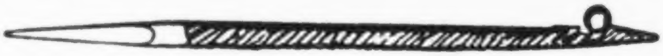
Answers to Frame 28: 1. 1. A 2. B 3. C

If you miss any of the following questions, go back and review the appropriate frame.

1. The part of the file used when filing is called the

   a. file heel. c. file face.

   b. file tang. d. file point.



2. The above pictured file is called a

   a. half-round file. c. taper file.

   b. rattail file. d. flat file.

3. The file best suited for sharpening saw blades is called a

   a. taper file. c. round file.

   b. rattail file. d. half-round file.

4. Rows of teeth on a file that criss-cross each other are called a

   a. bastard grade file. c. single-cut file.

   b. smooth grade file. d. double-cut file.

5. A file is properly used when

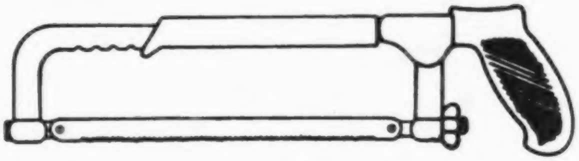
   a. only slight pressure is applied on the forward stroke.

   b. even pressure is applied on both, the forward and backward strokes.

   c. a smooth, firm, forward stroke is used.

   d. a lot of pressure is applied on the forward stroke, slight pressure is applied on the return stroke.

Frame 30 Continued



6. The above illustration represents

   a. an adjustable hacksaw.

   b. a solid frame hacksaw.

   c. a jig saw.

   d. a band saw.

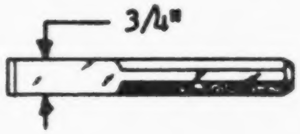
7. The tooth points on a hacksaw blade must

   a. be coarse enough to straddle the work.

   b. be very small in order to clear the chips away.

   c. face backwards, towards the handle.

   d. face forwards, towards the tip of the saw.



8. The above chisel is called a

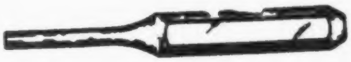
   a. cape chisel.   c. diamond point chisel.

   b. cold chisel.   d. drift chisel.

9. To cut a "V" groove in metal, you use a

   a. hacksaw.   c. diamond point chisel.

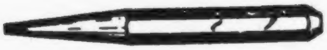
   b. flat chisel.   d. chassis chisel.



10. The above tool is called a

   a. drift punch.   c. center punch.

   b. pin punch.   d. chassis punch.



11. The above tool is called a

    a. drift punch.
    b. pin punch.
    c. center punch.
    d. chassis punch.

12. To mark the locations of holes to be drilled, you use a

    a. pin punch.
    b. drift punch.
    c. center punch.
    d. chassis punch.

13. To drive rivets or bolts out of holes, you use a

    a. pin punch.
    b. drift punch.
    c. center punch.
    d. chassis punch.

14. Chisels and punches that have become mushroomed should be

    a. used.
    b. thrown away.
    c. turned in for a new one.
    d. dressed on a grinding wheel.

Answers to Frame 29: 1. 1. B 2. A 3. C
2. 1. A 2. E 3. C 4. D 5. F 6. B

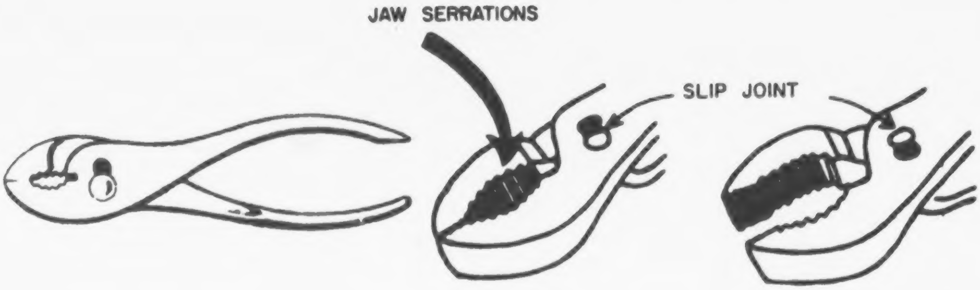
Frame 31

Pliers can be defined as tools designed to hold parts. They are made up of two pieces of steel pivoted off center. The application of pressure to the ends farthest from the pivot point will yield considerably more pressure at the end near the pivot point. Each of the different types of pliers available in the shop are made for one specific use. They should not be used as hammers or to remove and insert nuts and bolts.

NO RESPONSE REQUIRED

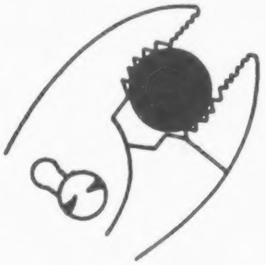
Answers to Frame 30:

Question No	Answer	Review Frame	Question No	Answer	Review Frame
1.	C	15	8.	B	25
2.	B	16	9.	C	26
3.	A	16	10.	B	28
4.	D	17	11.	A	28
5.	C	19	12.	C	29
6.	A	21	13.	A	29
7.	D	23	14.	D	27

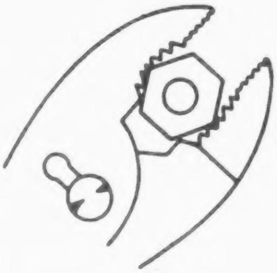


These are known as combination pliers. They have been called "gas" or "common" pliers in the past. Combination pliers are used to hold or bend small pieces of metal to the shape desired. Combination pliers have a slip joint that allows the jaws to be adjusted. This makes it possible to adjust the combination pliers so that they can be used to grip different sized objects.

Combination pliers may be used for many general operations but must never be used on nut and boltheads. To do so may damage the nut or bolt, and may damage the plier jaw serrations. Pliers usually mar the surface of any material, so be careful when using the tools.



YES



NO

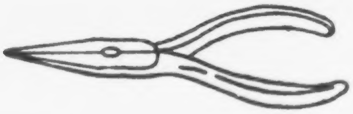
Check (✓) the true statement(s) below.

____ 1. Combination pliers can be adjusted to fit various size objects.

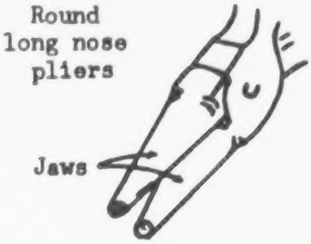
____ 2. Combination pliers may be used to loosen a nut, provided you are careful.

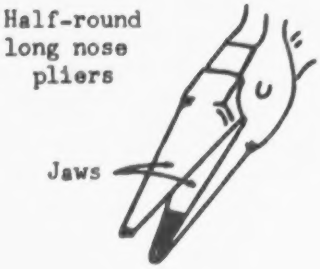
____ 3. Plier jaw serrations are sharp, and may damage material on which they are used.

Frame 33



The pliers shown above are called chain long nose pliers. They are commonly referred to as needle-nose pliers. These pliers are used to hold small parts; reach into spots where the hand can't get; make fine adjustments; and to form loops in electrical wire. The pliers may have various lengths of jaws and the jaws may be either round or half-round as shown in the drawings.





Check (✓) the true statement(s) below.

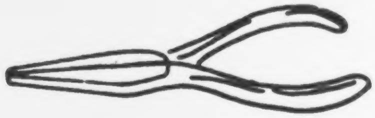
____ 1. Needle-nose pliers have a jaw that forms to a point.

____ 2. All long-nose pliers have half-round jaws.

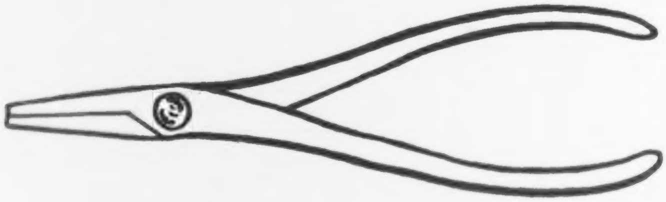
____ 3. Needle-nose pliers have slip-joints for size adjustments.

____ 4. Long-nose pliers are frequently used to form loops in electrical wire.

Answers to Frame 32: 1. ✓ 2. ____ 3. ✓



A pair of duckbill pliers are shown above. They are used almost exclusively when you are working with safety wire. The pliers have jaws that are long and flat, as shown in the drawing below.



Check (✓) the true statement(s) below.

____ 1. Duckbill pliers have round jaws.

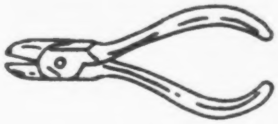
____ 2. Duckbill pliers have a squared jaw tip.

____ 3. Duckbill pliers have the same jaws as needle-nose pliers.

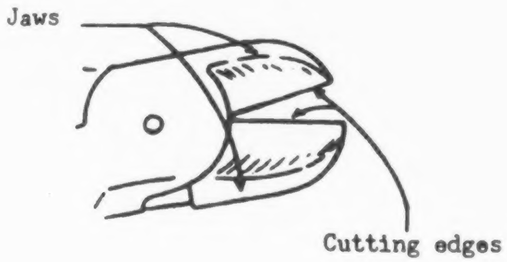
____ 4. Duckbill pliers are commonly used when working with safety wire.

Answers to Frame 33: 1. ✓ 2. ____ 3. ____ 4. ✓

Frame 35



The pliers shown above are diagonal cutting pliers or more commonly known as "dykes". The jaws have cutting edges used to cut safety wire, small electrical conductors or to remove cotter pins.



Diagonal cutters are only used to cut small size wire. These pliers can be easily damaged and should not be used to cut nails or similar objects. The wire to be cut should be placed as close to the pivot of the cutting jaws as possible and not at the points. This reduces the tendency to spring the jaws apart. Once the jaws are spread apart it is hard to cut small-sized wire. When using diagonal cutters, the inside of the cutting jaws should be pointed away from the user's face to prevent injury from flying clippings.

Check (✓) the true statement(s) below.

____ 1. Diagonal cutting pliers are also referred to as dykes.

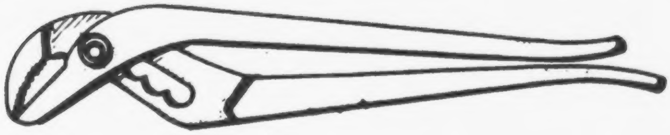
____ 2. When using diagonal cutters, cut with the tip or point of the jaws.

____ 3. A common hazard is flying objects when using diagonal cutters incorrectly.

____ 4. Duckbill pliers and diagonal cutting pliers are commonly used when working with safety wire.

____ 5. Diagonal cutting pliers are used to cut small wires.

Answers to Frame 34: 1. ____ 2. ✓ 3. ____ 4. ✓



The pliers shown above are technically known as water pump packing nut pliers. They were given this name because of the purpose they were first designed to serve; tightening the nut compressing the packing material around the water pump drive shaft on very early model cars. Now we call them just water pump pliers.

They are adjustable so as to grip large or small objects. Their long handles make possible a very strong grip. Their straight jaws give only two points of contact when used on large round objects. Because of this, they are likely to slip.

The slip joint feature of the water pump pliers makes them adjustable, so that different sizes of materials can be handled with them.

Check (✓) the true statement(s) below.

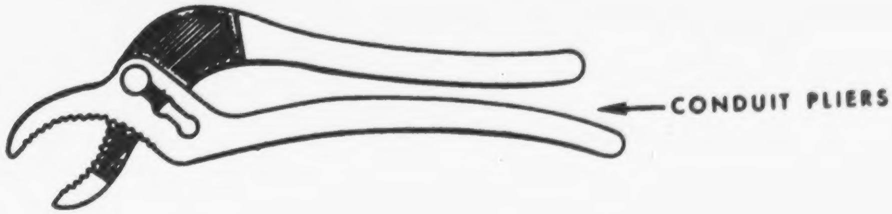
____ 1. Water pump pliers are adjustable in size.

____ 2. Water pump pliers grip large objects firmly because the jaw teeth provide complete contact around the object to be gripped.

____ 3. The long handles on the water pump pliers allow for a more powerful grip.

Answers to Frame 35: 1. _✓_ 2. ____ 3. _✓_ 4. _✓_ 5. _✓_

Frame 37



The pliers shown above are known as conduit pliers. Sometimes, they call them cannon plug pliers. If you compare the water pump pliers with the conduit pliers, they are almost the same. There are two main differences. The conduit pliers allow for a much larger grip. See how the jaws are curved. Also, the teeth of the jaws will grip the object firmly. See how the jaw teeth go all the way to the pivot point of the jaw. The teeth of the conduit pliers thus give contact all the way around the object to be gripped. Conduit pliers are used to loosen or tighten electrical conduit nuts or connections and cannon plugs.

Check (✓) the true statement(s) below.

____ 1. Conduit pliers have a slip joint.

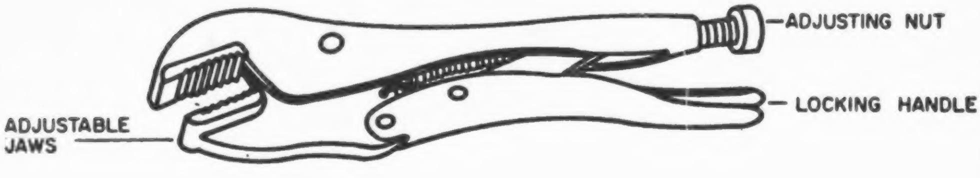
____ 2. Conduit pliers allow for a large grip.

____ 3. Conduit pliers are identical to water pump pliers.

____ 4. Conduit pliers have teeth around the complete gripping surface of the jaws.

Answers to Frame 36: 1. _✓_ 2. ____ 3. _✓_

The last pliers we want you to know is the wrench pliers, shown below.



This tool is commonly known as vise grips, for it is a combination of a wrench, a plier, and a vise. The adjustable jaws can be set by turning the adjusting nut at the end of one handle. When adjusted and the locking handle drawn into the locked position, it is like having the work locked in a vise.

You must take care not to use this tool on any machined surface that could be marred by the teeth of the vise jaws. The jaws can and will mark the surface of the material on which it is clamped.

This tool is handy for removing broken bolts when part of the bolt is still projecting.

1. Check (✓) the true statement(s) below.

_____ 1. Wrench pliers hold the work like vise grips.

_____ 2. Wrench pliers have a slip joint for size adjustment.

_____ 3. The locking handle must be drawn in the locked position for the work to be locked in the jaws.

Answers to Frame 37: 1. __✓__ 2. __✓__ 3. _____ 4. __✓__

Frame 39

Pliers are made in a wide range of sizes so not to overstrain and perhaps break something. Judgment must be used to pick pliers heavy and large enough for the job at hand. Do not use pliers as wrenches to tighten or loosen nuts. Pliers will damage the flats or round off the corners of nuts or bolts.

When cutting wire which is springy or under tension, caution must be used. The wire will try to whip. To stop this, one end of the wire should be held securely and your body turned or shielded from the loose end.

There is a common tendency among inexperienced mechanics to use pliers as all-purpose tools. The pliers are intended to aid the mechanic when installing and removing safety wire and cotter pins; to hold those materials which the hand alone is not strong enough to hold; and to hold materials which are hot, such as connections being soldered.

Check (✓) the true statement(s) below.

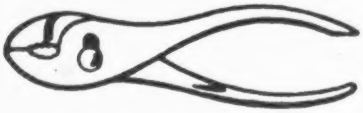
____ 1. Pliers take the place of a wrench, if no wrench is handy.

____ 2. Pliers can be considered as an all-purpose tool.

____ 3. You must use judgement when selecting pliers.

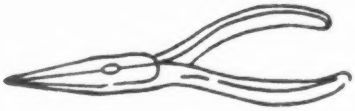
Answers to Frame 38: 1. 1. ✓ 2. ____ 3. ✓

Answer the following questions concerning pliers. After checking the answers at the end of the next frame, and if you missed any questions, review the appropriate frames.



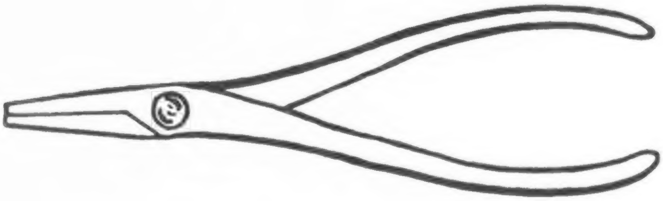
1. The above pliers are referred to as

   a. water pump pliers.
   b. conduit pliers.
   c. combination pliers.
   d. wrench pliers.



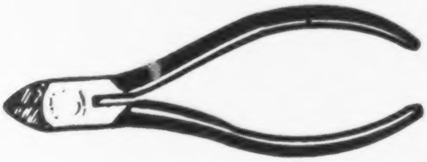
2. The above pliers are referred to as

   a. duckbill pliers.
   b. needle-nose pliers.
   c. combination pliers.
   d. conduit pliers.



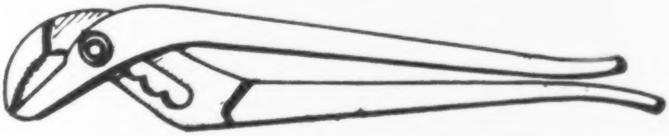
3. The above pliers are referred to as

   a. needle-nose pliers.
   b. long-nose pliers.
   c. combination pliers.
   d. duckbill pliers.



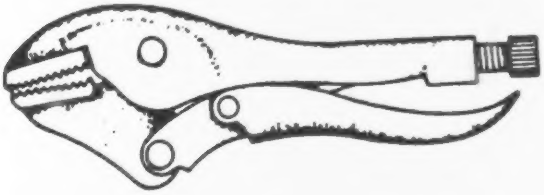
4. The above pliers are often referred to as

a. dykes.
c. vise grips.
b. combination pliers.
d. wrench pliers.



5. The above pliers are often referred to as

a. conduit pliers.
c. water pump pliers.
b. cannon plug pliers.
d. wrench pliers.



6. The above pliers are often referred to as

a. wrench pliers.
c. conduit pliers.
b. combination pliers.
d. water pump pliers.

7. Combination pliers are commonly used to

a. turn a nut.
c. bend a piece of metal.
b. cut a wire.
d. tighten a bolt.

8. To form loops in electrical wire, you would use
   - a. duckbill pliers.
   - b. dykes.
   - c. wrench pliers.
   - d. needle-nose pliers.

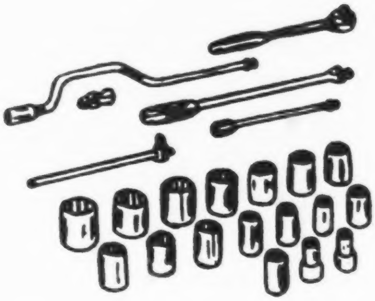
9. Dykes are commonly used to
   - a. bend a piece of metal.
   - b. cut a small wire.
   - c. turn a bolt.
   - d. hold a pipe.

10. To loosen a cannon plug, you would use
   - a. water pump pliers.
   - b. conduit pliers.
   - c. wrench pliers.
   - d. combination pliers.

Answers to Frame 39: 1. ____ 2. ____ 3. ✓

Frame 41

Socket sets, as shown in the illustration, are made up of different combinations of handles, adapters, universal joints, and sockets. Where applicable and practical, a socket wrench is the best tool for removing nuts and bolts. They should be the mechanics first choice of wrenches. However, when reassembling parts of an aircraft or engine, the socket wrench should be used with caution.



Answer each of the following statements as either true (T) or false (F).

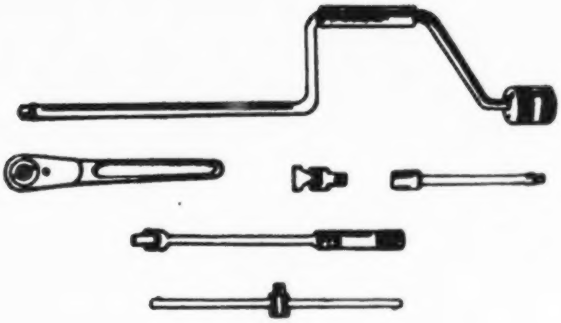
_____ 1. The socket set should be the mechanics first choice of wrenches.

_____ 2. The socket set is made up of a variety of handles, extensions, universal joints, and a variety of sizes of sockets.

_____ 3. The socket wrench is the best tool for removing nuts and bolts wherever practical.

Answers to Frame 40:

Question No	Answer	Review Frame	Question No	Answer	Review Frame
1.	C	32	6.	A	38
2.	B	33	7.	C	32
3.	D	34	8.	D	33
4.	A	35	9.	B	35
5.	C	36	10.	B	37



Where applicable and practical, the socket wrench set is the best tool for removing/installing nuts and bolts. However, the set should be used with caution. The available handles are interchangeable. They are made long enough to enable the mechanic to tighten the largest nuts or bolts without undue strain. If a long handle is used while turning a small nut or bolt, there is the possibility that enough twisting force (torque) will be exerted to strip the threads or pull the bolt in two. However, if the user holds the handle near the socket, instead of at the end of the handle, a long handle may be used satisfactorily.

Some of the more commonly used accessories and handles for use with the socket wrench set are shown in the illustration above. Our experience has lead us to conclude that everybody needs to have a few words of explanation concerning the purpose, care, and use of some or all of these tools.

Check (✓) the correct statement(s) below.

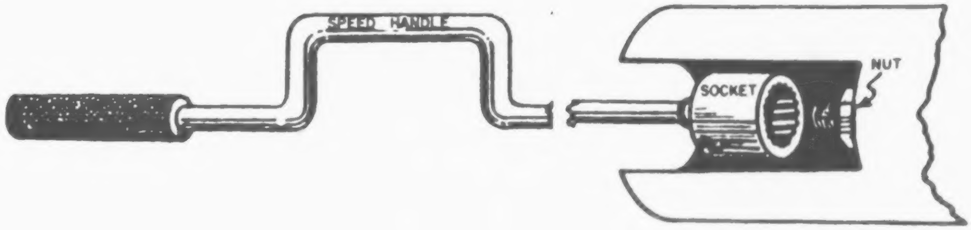
____ 1. Socket wrench handles are interchangeable.

____ 2. The larger the handle, the more torque can be obtained.

Answers to Frame 41: 1. T 2. T 3. T

Frame 43

Sockets are used with a variety of handles. It is this variety that makes sockets the first choice of wrenches. If the work area has plenty of room or "swing space" the speed handle should be used to remove nuts or bolts quickly. The speed handle is held with one hand and the crank is held with the other hand. The long neck of the speed handle allows access to recessed nuts or bolts.



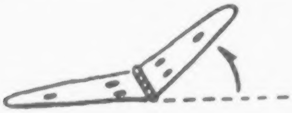
Answer the following statements as either true (T) or false (F).

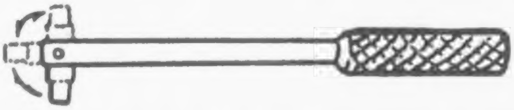
____ 1. The speed handle is used where the turning radius is limited.

____ 2. Nuts and bolts can be removed quickly with a speed handle.

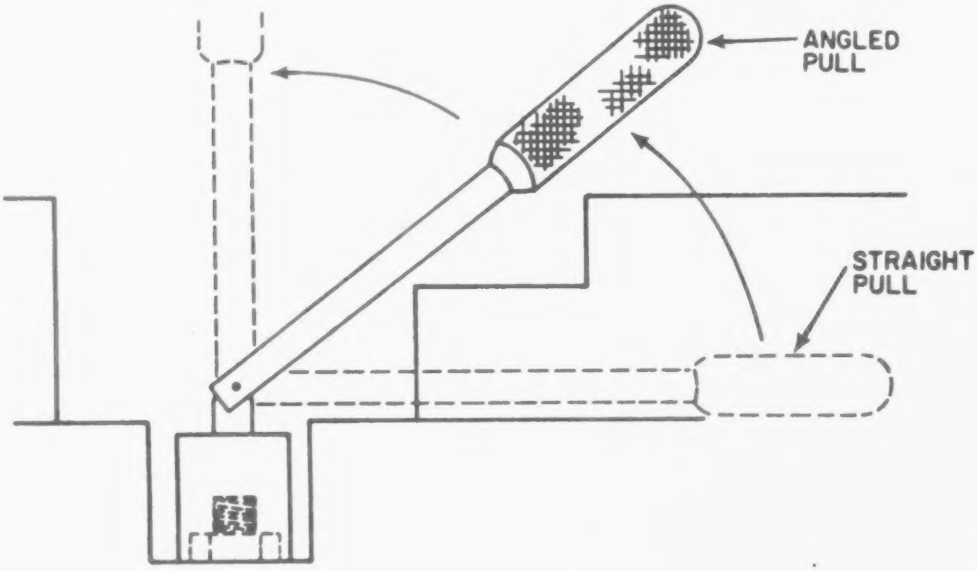
Answers to Frame 42: 1. _✓_ 2. _✓_

Sometimes a lot of leverage is required to move a stubborn nut. The hinge handle can provide this leverage. This handle is so named because it is designed like a door hinge.





The hinge handle is the strongest handle in the toolbox. Because of this, it is used to break loose stubborn nuts and bolts. To loosen a nut, the handle can be used at right angles to the socket for a straight pull. This is shown in the figure below. If this is not possible, an angled pull may be used. After the nut is loosened, the handle can be moved on its hinge to the vertical position and twisted by the fingers to remove the nut.



Frame 44 Continued

Answer each of the following statements as either true (T) or false (F).

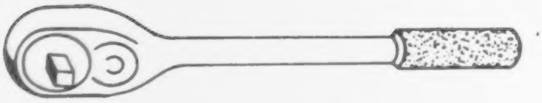
____ 1. The hinge handle can be used for a straight (90 degree) pull if desired.

____ 2. The hinge handle will provide any angle of pull desired.

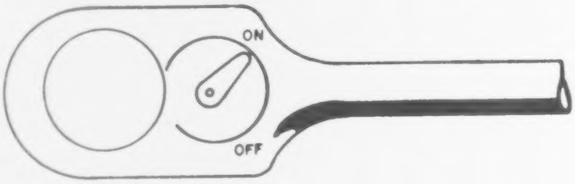
____ 3. Tight or "stubborn" nuts or bolts should be loosened with the hinge handle.

Answers to Frame 43: 1. F 2. T

Frame 45



One of the most useful handles is called a ratchet handle. (See above figure). This handle can be used to either tighten (put on) a nut, or loosen (take off) a nut. The figure below shows a ratchet handle set to tighten (put on) a nut. Many ratchet handles don't have the direction of the turn marked. These handles require a check to see in which direction (way) they are set to turn. By grasping the handle in one hand and the drive in the other, you can quickly determine which way the ratchet will turn or drive. This handle allows you to tighten or loosen a nut in a limited space without having to remove and reposition the socket on the nut. The handle slips (ratchets) one way, but will not slip the other way. To change the setting of the ratchet, merely move the control lever to its other position.



Never use a ratchet handle to break nuts or bolts loose. Using a solid handle or a box-end wrench will avoid damaging the ratchet handle.

Answer the following statements as either true (T) or false (F).

____ 1. The ratchet handle drives in one direction and slips in the other.

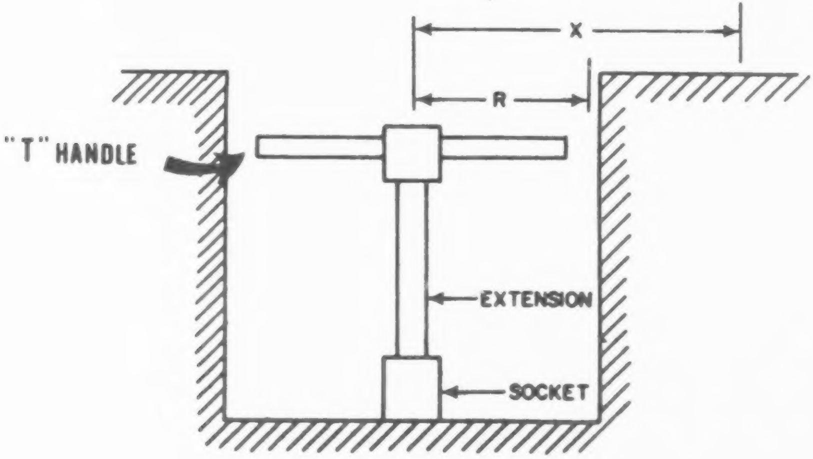
____ 2. When you can't get a straight pull on a nut, the ratchet handle will permit an angled pull.

____ 3. The ratchet handle can be operated without having to raise the socket off the nut for another "bite".

Answers to Frame 44: 1. T 2. T 3. T

Frame 46

The T-handle is yet another type of handle used for driving sockets. The "T" makes it possible to put on the same force with both hands because the drive is in the center. Another advantage is that the turning radius is smaller than that needed with other handles, as shown in the illustration below. "R" shows the radius for the T-handle. "X" shows the radius needed for another type of handle.



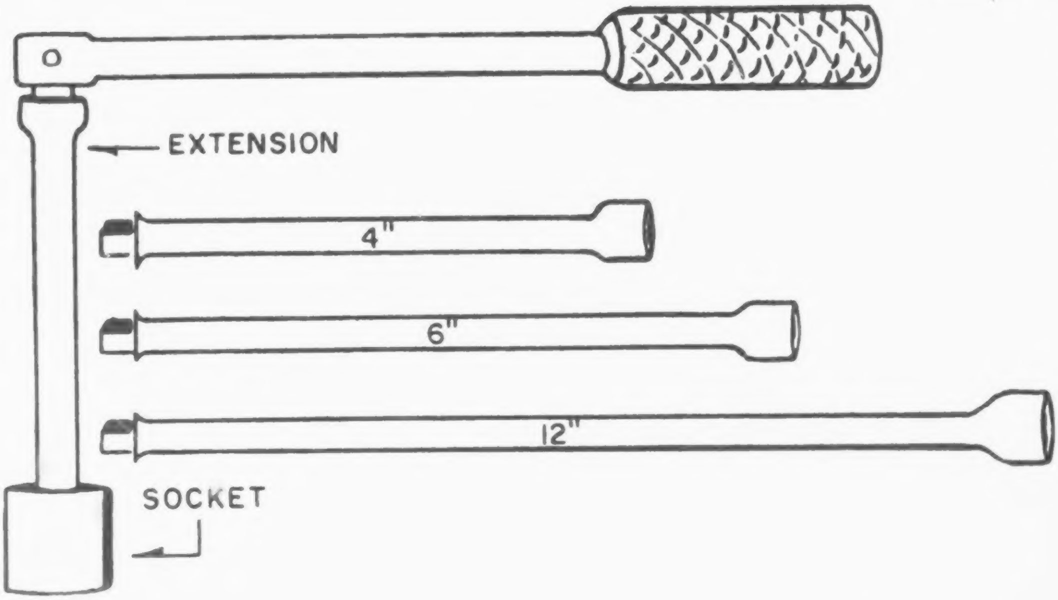
Check (✓) the correct statement(s) below.

____ 1. Both hands can be used to apply equal force to the "T" handle.

____ 2. A large turning radius is required to use the "T" handle.

____ 3. When you use a socket you should use a hinge or "T" handle to loosen a "tight" nut.

Answers to Frame 45: 1. T 2. F 3. T



An "extension" is used to make something longer. If the socket handle that is used is not long enough to reach to the nut or bolt, an extension bar is put between the socket and its driving handle. Extensions are made in different lengths. We even have flexible extensions that further increase the useability of the socket wrench set.

Check (✓) the correct statement(s) below.

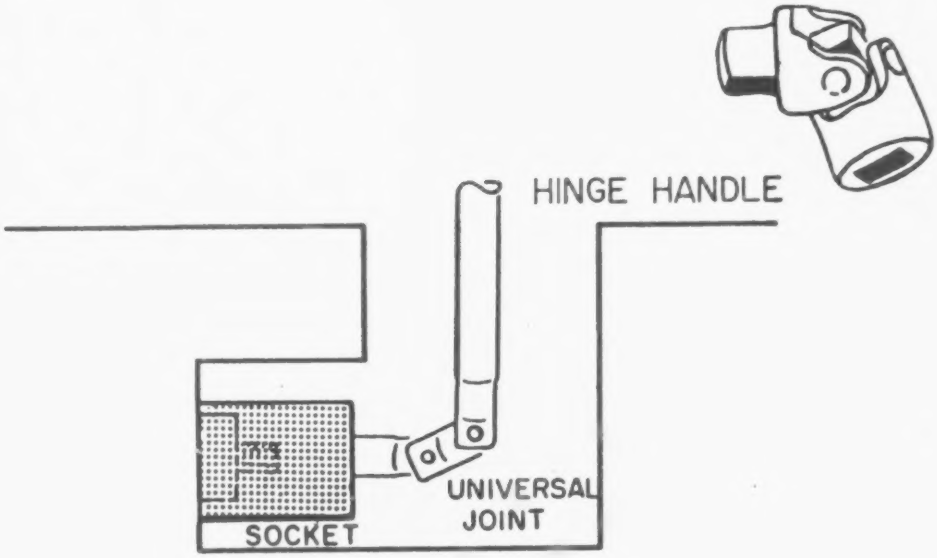
____ 1. The socket extension should always be used with the ratchet handle.

____ 2. An extension is used between the socket and the socket handle to reach nuts and bolts at various lengths.

Answers to Frame 46: 1. ✓ 2. ____ 3. ✓

Frame 48

Universal means "all". With the universal joint, you can apply force in all directions. Since the universal joint is intended to be used between the socket and the socket handle, it has a male end and a female end. To turn a nut located in a hard-to-get-at place, you would use a universal joint as illustrated below.



Check (✓) the correct statement(s) below.

____ 1. Universal joints permit work where a straight wrench cannot be used.

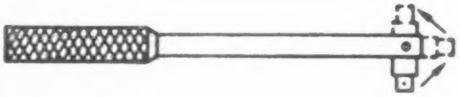
____ 2. Universal joints have two male ends.

____ 3. Universal joints can apply force in all directions.

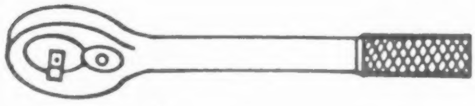
Answers to Frame 47: 1. ____ 2. ✓

Frame 49

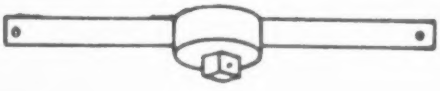
A



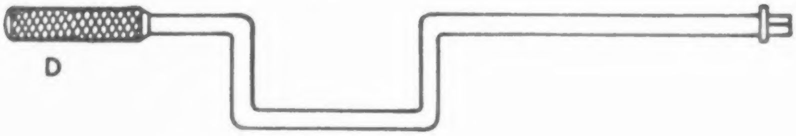
B



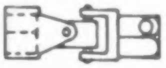
C



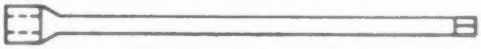
D



E



F



1. Identify the above tools by writing their respective letters next to their nomenclature in the space provided.

____ 1. Ratchet handle

____ 2. Extension

____ 3. Speed handle

____ 4. "T" handle

____ 5. Hinge handle

____ 6. Universal joint

Frame 49 Continued

2. Match each tool in column B with the proper use in column A.

Column A

____ 1. When the fast removal or replacement of nuts and bolts is required, and the swing arc is not limited.

____ 2. For breaking nuts and bolts loose and to permit the freedom of any angle of pull desired.

____ 3. To tighten or loosen a nut, without having to remove and reposition the socket on the nut.

____ 4. When the turning radius is small or when a nut or bolt must be reached through a bulkhead.

____ 5. Used if the socket handle drive isn't long enough or if the working area restricts the movement of tools.

____ 6. Used between the socket and the socket handle, to reach nuts and bolts at various angles.

Column B

A. T-handle

B. Ratchet handle

C. Speed handle

D. Hinge handle

E. Socket

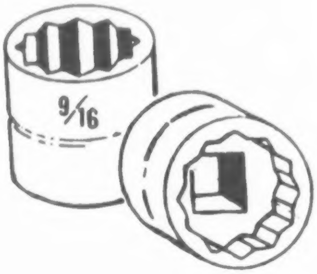
F. Extension

G. Universal joint

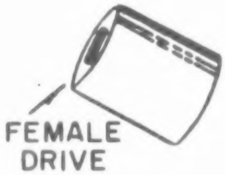
H. Adapter

Answers to Frame 48: 1. ✓ 2. ____ 3. ✓

Your toolkit will have several sockets to fit various sizes of nuts and handles. The first choice of experienced mechanics, when faced with the tightening or loosening of nuts and bolts, is the socket wrench. One reason for his choice is that sockets have more contact area and are less likely to slip. Most sockets in use in the Air Force have 12 gripping points. Repositioning of the socket for another turn is easy since the socket will fit on a nut or bolt in many different positions.



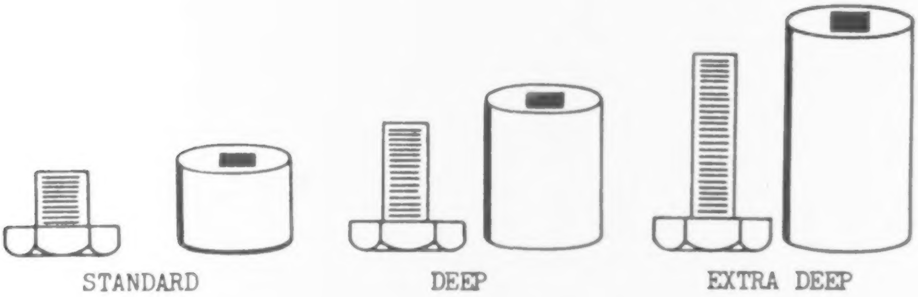
Sockets are not adjustable. They come in sets and each individual socket will fit only one size nut or bolt. The size nut or bolthead a socket will fit is plainly stamped into the side of each socket. The illustration above shows a socket that will fit a 9/16 inch bolt or nut head.



The square opening in the head of a socket, where the driving handle is attached, is called the female drive, illustration above. Sockets are not only sized according to the size nut or bolt they will fit, but also by the size of the drive that is used to turn them. Standard drives in common use are 1/4", 3/8", and 1/2".

Frame 50 Continued

Another thing to be considered when sizing sockets is the depth. In order to reach a nut turned way down on a long bolt, the socket would have to have considerable depth. Sockets are further classified as standard (shallow), deep, and extra deep.



Check (✓) the true statement(s) below.

____ 1. The socket-drive hole (female drive) must be the same size as the square drive on the wrench handle.

____ 2. The number stamped on the socket refers to the size of the drive.

____ 3. The female drive of a socket must fit the nut or bolt to be removed.

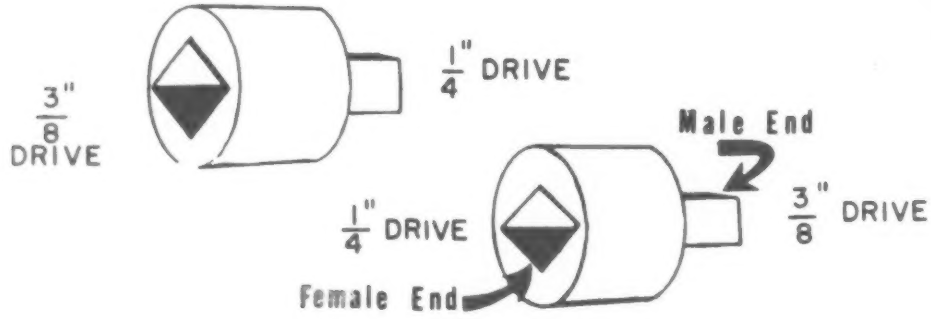
____ 4. When selecting a socket, one must consider the size of the nut or bolt, the size of the drive, and the depth of the socket.

____ 5. The number stamped on the socket refers to the size of the bolt to be worked on.

____ 6. The standard socket refers to the shallowest socket.

Answers to Frame 49: 1. 1. B 2. F 3. D 4. C 5. A 6. E
2. 1. C 2. D 3. B 4. A 5. F 6. G

Sometimes you will have a socket with a 1/4" drive and a handle with a 3/8" drive. These can be adapted to each other by use of an adapter. The male and female drives of the adapters are of different sizes. The addition of this device to the socket wrench set makes it possible to reduce the total number of tools required to be carried to a job and provides greater useability of those required on the job.



Check (✓) the correct statement(s) below.

____ 1. One end of the adapter fits the bolt or nut to be removed or installed.

____ 2. The female part of the adapter fits the handle.

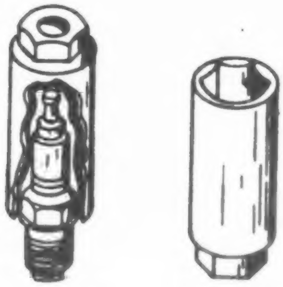
____ 3. The male part of the adapter fits the socket.

____ 4. Both ends of the adapter are the same size.

Answers to Frame 50: 1. ✓ 2.____ 3.____ 4. ✓ 5. ✓ 6. ✓

Frame 52

A socket is available to ease the installation or removal of spark plugs. The spark plug holding socket has six points that grip the spark plug closely. This tight grip prevents the socket from dropping and breaking the porcelain on the spark plug during its removal or installation.

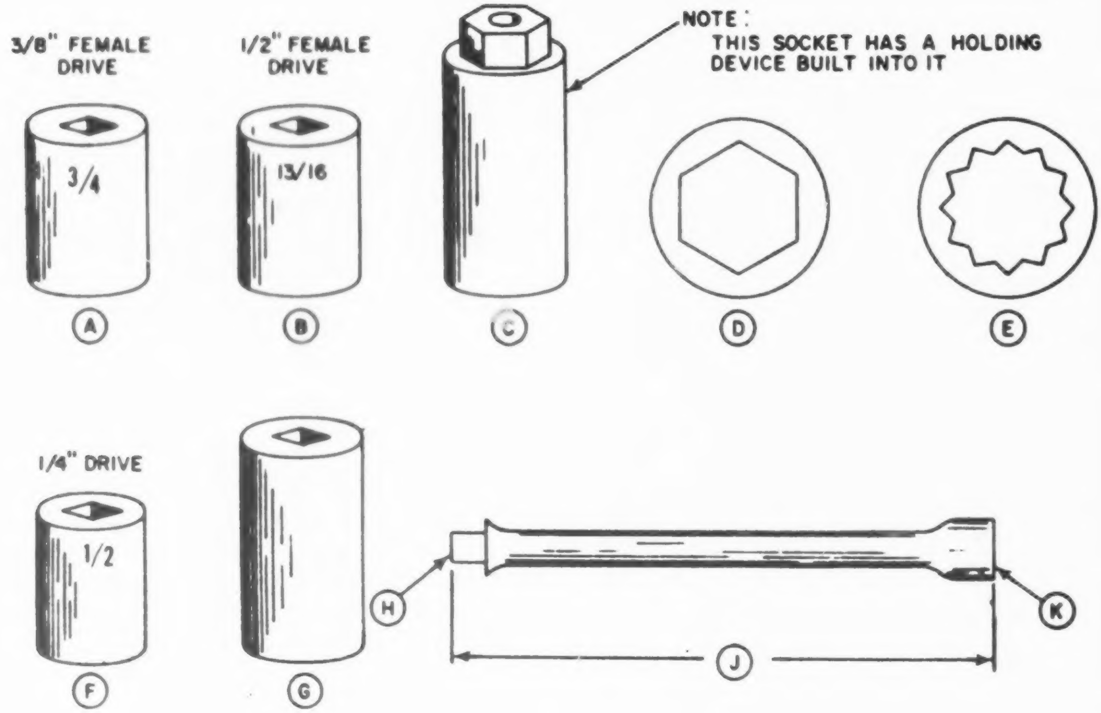


Check (✓) the correct statement(s) below.

____ 1. The spark plug holding socket has six points.

____ 2. The spark plug holding socket has a holding device built into it to grip and hold the spark plug in the socket.

Answers to Frame 51: 1.____ 2.__✓__ 3.__✓__ 4.____


3/8" FEMALE DRIVE
1/2" FEMALE DRIVE
NOTE:
THIS SOCKET HAS A HOLDING DEVICE BUILT INTO IT
3/4
13/16
A
B
C
D
E
1/4" DRIVE
1/2
F
G
H
J
K

1. Match the items illustrated above with the statements listed below.

____ 1. Spark plug holding socket

____ 2. Six point socket

____ 3. 12 point socket

____ 4. Male drive end

____ 5. Female drive end

____ 6. Extension length

___ ___ ___ 7. Standard socket

____ 8. Deep socket

____ 9. 1/2" square drive socket, 13/16" size

___ 10. 3/8" square drive socket, 3/4" size

___ 11. 1/4" square drive socket, 1/2" size

___ 12. The socket required to turn a 3/4" nut with a 3/8" male drive handle

Frame 53 Continued

2. Answer each of the following statements as either true (T) or false (F).

____ 1. The size of socket drives (handles) is determined by the dimension of the square end of the drive and the square hole in the socket.

____ 2. Due to the various choices of handles, and the variety of drives and adapters, the socket wrench can be used for many different jobs.

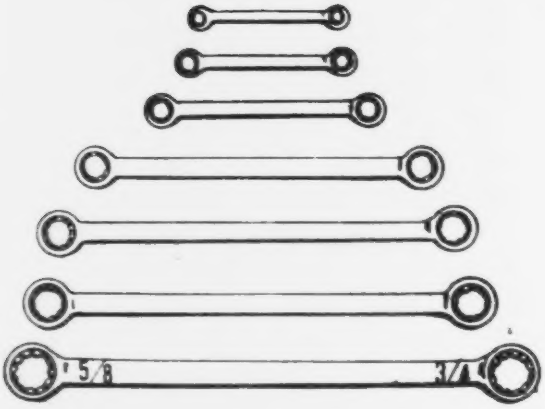
____ 3. The spark plug holding socket has a holding device built into it to grip and hold the spark plug in the socket so that it will not fall out during removal or installation.

____ 4. The purpose of a wrench is to tighten or loosen nuts and bolts.

____ 5. An adapter has different size ends.

Walk over to the handtool trainer and look at the many handles, sockets, and attachments available.

Answers to Frame 52: 1. ✓ 2. ✓



This is a set of box-end wrenches. A box-end wrench is essentially a bar with a socket on each end.

These wrenches are used for general work and they are well suited for operation in close quarters.

Their heads are small and yet they completely surround the object being worked on. They can be used on nuts which cannot be gripped by other types of wrenches. Most box-end wrenches have twelve points and almost all nuts and bolts have six sides. Therefore, as little as one-twelfth of one turn can be taken each time the wrench is shifted.

Box-end wrenches may be further identified as being "offset". This means that the head is offset (bent off to one side) by an angle of 15 degrees from the handle. This is to provide clearance for the user's hand and prevent "barking" of his knuckles.

Check (✓) the correct statement(s) below.

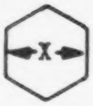
____ 1. A box-end wrench has a socket on each end.

____ 2. Each end of the box-end wrench is a different size.

____ 3. All box-end wrenches are straight.

Answers to Frame 53: 1. 1. C 2. D 3. E 4. H 5. K 6. J 7. A,B,or F
8. G 9. B 10. A 11. F 12. A
2. 1. T 2. T 3. T 4. T 5. T

Frame 55



Nut and boltheads are measured and their sizes expressed as the distance between two opposite "flats". See the figure above.

The length of box-end wrenches is proportional to the size of the nut it fits. The sizes of box-end wrenches are stamped into the metal near each end. The proportional sizing of box-end wrenches makes them good tools to use for the final setting of nuts or bolts. The mechanic is not so apt to overtighten the nut so that he strips the threads or pulls the bolt apart.

Check (✓) the correct statement(s) below.

____ 1. Nut and bolthead sizes are determined by measuring from corner to corner.

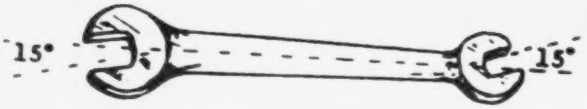
____ 2. Small box-end wrenches have large handles.

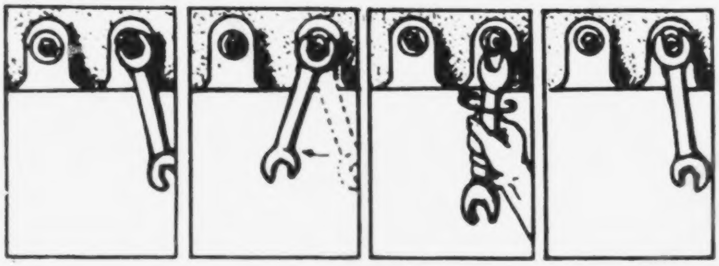
____ 3. The size of the box-end wrench is stamped in the metal, near the end.

____ 4. The smaller the box-end wrench socket, the smaller the handle.

____ 5. The longer the box-end wrench handle the more torque can be applied.

Answers to Frame 54: 1. ✓ 2. ✓ 3. ____





Open-end wrenches are open at the ends. They can be used on tubing nuts and in other places where it would be impossible to use a box-end or other type of wrench. The open-end wrench should be used only when conditions make it impossible to use the box-end wrench. The box-end wrench bears against the nut or bolthead on six points. However, the open-end wrench bears against the same nut or bolthead at only two points. This two point contact is apt to lead to rounding off the corners of the nuts or bolts on which the open-end wrench is used.

Open-end wrenches fit standard sized nuts and are light, strong, and convenient for working in limited space. The distance between jaws determines the size of the nut it will fit. Because the jaws are set at an angle, usually 15 degrees, it is easy to increase the swing of the handle by turning the wrench over. The length of the wrench varies according to the size of the opening, which is plainly stamped near each end of the wrench.

Check (✓) the correct statement(s) below.

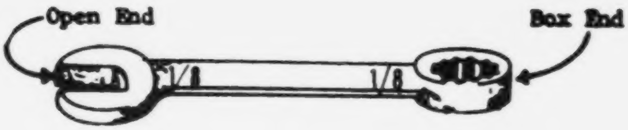
____ 1. The open-end wrench is better than the box-end wrench when removing bolts.

____ 2. The jaws of an open-end wrench are usually set at a 15 degree angle.

____ 3. The length of the wrench varies according to the size of the opening.

Answers to Frame 55: 1.____ 2.____ 3.__✓__ 4.__✓__ 5.__✓__

Frame 57



Combination wrenches are designed to provide a box-end on one end and the same size open-end on the other end.

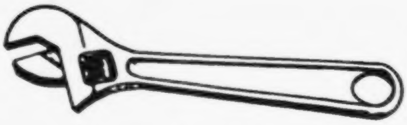
The combination wrench is used to loosen and tighten nuts and bolts. The box-end is used to "break" the nuts and bolts free, then the open-end can be used to remove or replace the nuts and bolts more quickly.

Check (✓) the correct statement(s) below.

____ 1. A combination wrench has the same size open-end as box-end on each side of the wrench.

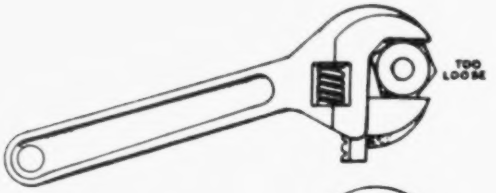
____ 2. The open-end of the combination wrench is set at a 15 degree angle.

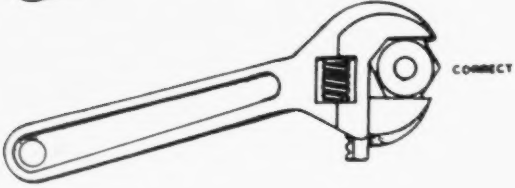
Answers to Frame 56: 1.____ 2.✓ 3.✓

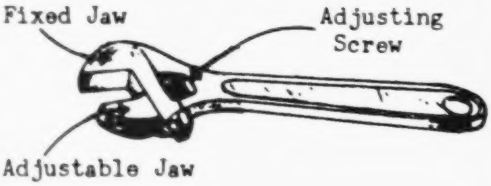


This is an open-end adjustable jaw wrench. It is made so its jaws can be opened or closed to fit the flats of the nut or bolthead. The face of each jaw is smooth. The size of the wrench is given in inches, which is the overall length of the tool.

The adjustable jaw wrench is the most commonly misused tool available to the mechanic. Normally, it should be used only when other wrenches are not available or do not fit the nuts or bolts to be worked on. For minor adjustments, where the torque required is not too great, this wrench works satisfactorily. Care should be exercised because this wrench is more apt to round off the corners than one which fits perfectly.







Shaking the wrench slightly, while it is being adjusted to the nut or bolt size, will aid in getting a more nearly perfect fit.

Check (✓) the correct statement(s) below.

____ 1. The correct way to determine the size of an adjustable jaw wrench is to measure the maximum jaw opening.

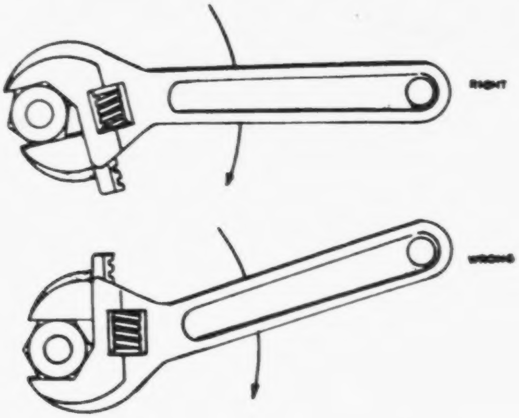
____ 2. Adjustable jaw wrenches should be used where the turning effort (torque) is not too great.

____ 3. Shaking the wrench, while making the size adjustment, aids in getting a better fit.

Answers to Frame 57: 1. ✓ 2. ✓

Frame 59

The adjustable jaw wrench should always be turned in the proper direction. All adjustable jaw wrenches should always be pulled so that the handle moves toward the adjustable jaw. If an adjustable jaw wrench is turned over and used so that the pressure is on the main jaw, it is very likely that the adjustable jaw will break.



This tool is commonly known as the "knuckle buster" for it is prone to slip from the part being worked on. Always place the wrench in a position so that the pull on the handle tends to force the jaws further onto the nut. The most effective angle for this pulling is with the arm at right angles to the handle and the center line of the nut or bolt. This helps prevent wrench slippage.

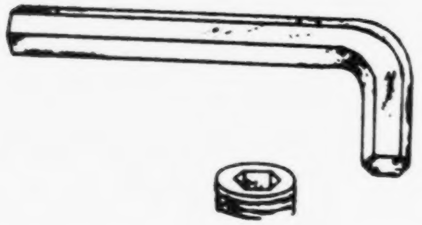
Check (✓) the correct statement(s) below.

____ 1. The correct way to use an adjustable jaw is to push it toward the adjustable jaw.

____ 2. Incorrect use of the adjustable jaw wrench can cause slippage.

____ 3. Adjustable jaw wrenches should always be pulled so that the handle moves toward the adjustable jaw.

Answers to Frame 58: 1.____ 2.__✓__ 3.__✓__



To the old-timer, the object shown above is known as an "Allen wrench". Technically, it is a "key, socket head screw".

Regardless of what it is called, the tool is a hexagonal steel bar with a 90 degree bend. The longer portion is normally considered to be the handle, although both ends are the same size and can be used interchangeably. The size of the tool is found by measuring the distance across the flat tip or end.

Whereas most wrenches fit outside of a nut or bolt, this key fits inside the head of a bolt or screw. These tools are used to turn screws and setscrews used to fasten pulleys to shafts where the head of a conventional screw would interfere with operation. This "working from the inside" feature has lead some people to call this tool an "internal wrenching" key.

Check (✓) the correct statement(s) below.

____ 1. An "Allen wrench" is designed for internal wrenching bolts.

____ 2. Only the short end of the key socket head screw is used to tighten setscrews.

____ 3. The Allen wrench is six sided.

Answers to Frame 59: 1.____ 2.__✓__ 3.__✓__

Frame 61

Never use a wrench as a hammer or crowbar.

Stop pulling on the nut as soon as it is turned down tight. If a definite tightness is specified, you will have to use a torque wrench to complete technical publications requirements.

Always think twice before pushing on a wrench. If you are standing on a wet surface there is the possibility that you may fall flat on your face. Ten chances to one you will find it safer to pull. If the wrench must be pushed, use the palm of your open hand so that your knuckles will not be mashed in case something does slip.

See that your footing is good before you pull. Get into the habit of figuring out what is going to happen when the wrench slips, the bolt breaks, or the threads strip. Particular care should be taken when working on a ladder, stand, or in any elevated position.

Never use a pipe or another wrench to extend the handle of a wrench in order to gain leverage. Something is bound to give - but maybe not what you expect.

Inspect all wrenches frequently for general condition, cleanliness, chips, cracks, etc. Avoid throwing wrenches or other tools into your toolbox.

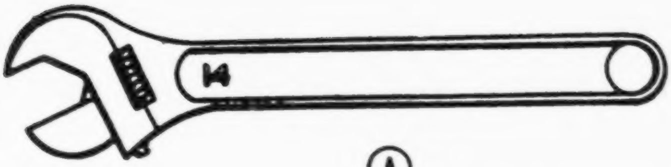
Check (✓) the correct statement(s) below.

____ 1. A wrench is a universal tool, it can be used as a substitute for many coomon handtools.

____ 2. Never push a wrench.

____ 3. A pipe may be used to extend the length of a wrench.

Answers to Frame 60: 1.__✓__ 2.____ 3.__✓__



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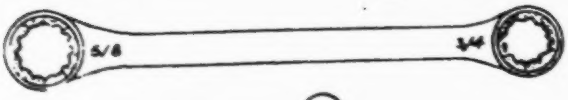

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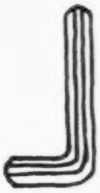

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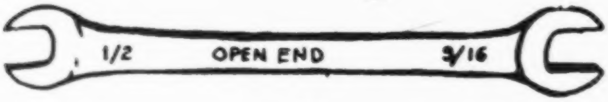
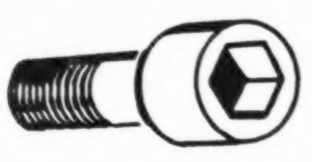
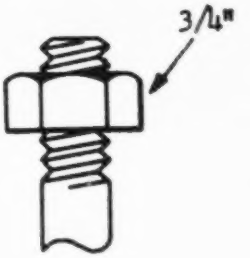

1/2
OPEN END
9/16

Ⓒ

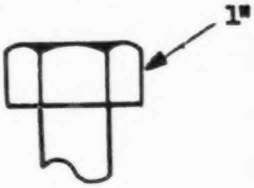
1. Study the sizes of the wrenches shown above: THEN place the letter of the proper wrench to be used for each nut or bolt in the spaces provided below.



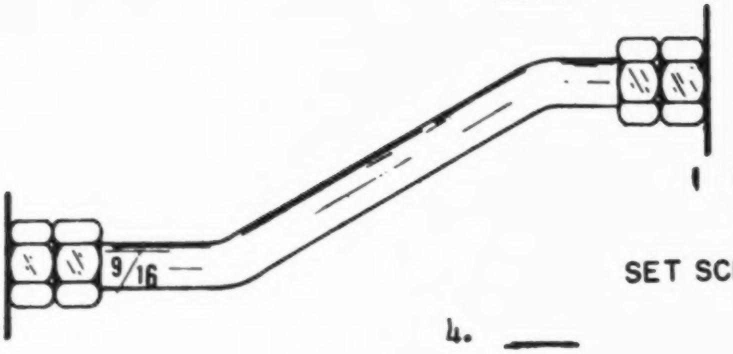
1.____



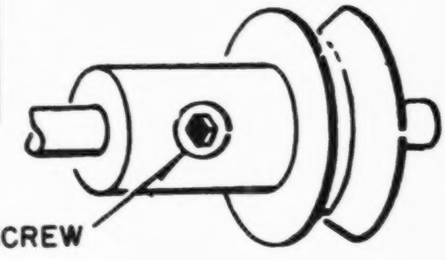
2. ____



3. ____



4. ____



5. ____

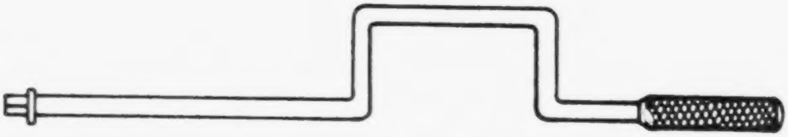
Frame 62 Continued

2. The uses of wrenches are listed in column A, the types of wrenches are listed in column B. Match each wrench in column B with its proper use in column A.

Column A	Column B
____ 1. Used on internal wrenching hexagon bolts, plugs, and setscrews.	A. Open-end wrench.
____ 2. Must be used on gas and oil line fittings.	B. Adjustable jaw wrench.
____ 3. Used in hard to reach places. It completely surrounds the bolthead or nut to be turned.	C. Socket screw wrench.
____ 4. Will fit any bolt or nut within its range and works satisfactorily for adjustments, or where the turning effort (torque) is not too great.	D. Box-end wrench.

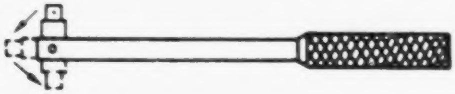
Answers to Frame 61: 1.____ 2.__✓__ 3.____

Answer the following questions concerning wrenches. If you missed any questions, review the appropriate frames.



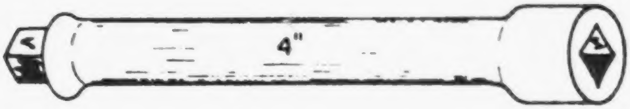
1. The above tool is called a

a. hinge handle.
b. ratchet handle.
c. "T" handle.
d. speed handle.



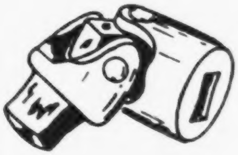
2. The above tool is called a(n)

a. hinge handle.
b. speed handle.
c. ratchet handle.
d. extension.



3. The above tool is called a(n)

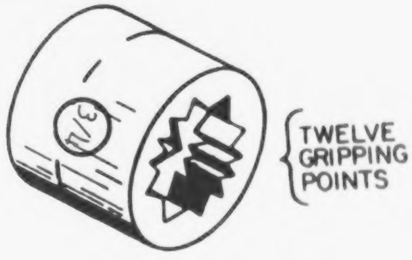
a. hinge handle.
b. extension.
c. universal joint.
d. socket.



4. The above tool is called a(n)

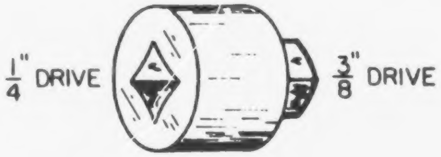
a. extension.
b. swivel socket.
c. universal joint.
d. shallow socket.

Frame 63 Continued


3/4
TWELVE GRIPPING POINTS

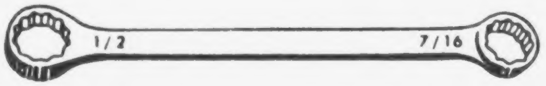
5. The above socket will fit a

   a. 3/4" bolthead.
   b. 3/4" drive.
   c. any size bolthead.
   d. 3/4" drive and 3/4" bolthead.


1/4" DRIVE
3/8" DRIVE

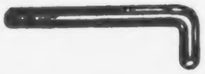
6. The above tool is called a(n)

   a. universal joint.
   b. adapter.
   c. socket.
   d. adjustable wrench.



7. The above tool is called a(n)

   a. open-end wrench.
   b. box-end wrench.
   c. combination wrench.
   d. adjustable wrench.



8. The above tool is sometimes called a(n)

   a. screwdriver.
   b. socket wrench.
   c. Allen wrench.
   d. external wrench.

9. The best tools for removing nuts and bolts wherever practical are

   a. adjustable jaw wrenches.

   b. combination pliers.

   c. socket wrenches.

   d. open-end wrenches.

10. Speed handles are used where

    a. the turning radius is limited.

    b. speed is required.

    c. an angle pull is required.

    d. tight nuts must first be broken loose.

11. Which of the following socket handles drives in one direction and slips in the other direction?

    a. Hinge handle.

    b. Speed handle.

    c. Ratchet handle.

    d. "T" handle.

12. Which socket handle can be operated without having to raise the socket off the nut for another "bite"?

    a. Hinge handle.

    b. Ratchet handle.

    c. Speed handle.

    d. "T" handle.

13. To get to a nut located in a hard-to-get-at place, you would use a(n)

    a. adapter.

    b. universal joint.

    c. "T" handle.

    d. speed handle.

14. The socket-drive hole (female drive)

    a. has its size stamped on the side of the socket.

    b. fits any size socket handle.

    c. must be the same size as the bolt.

    d. is attached to the socket handle.

Frame 63 Continued

15. To reduce the total number of tools required to be carried to a job, it would be best to carry which of the following tools?

    a. Universal joint.
    b. Speed handle.
    c. Adapter.
    d. Extension.

16. Which of the following tools is best suited to remove a nut?

    a. Box-end wrench.
    b. Open-end wrench.
    c. Adjustable jaw wrench.
    d. Pliers.

17. Which of the following wrenches will yield the largest amount of torque?

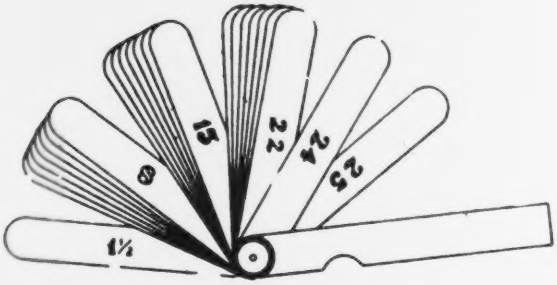
    a. Short handled, open-end wrench.
    b. Long handled, box-end wrench.
    c. Adjustable jaw wrench.
    d. Short handled, box-end wrench.

18. What is the correct way to use an adjustable jaw wrench?

    a. Push it toward the adjustable jaw.
    b. Pull it toward the stationary jaw.
    c. Pull it toward the adjustable jaw.
    d. Push it toward the stationary jaw.

Answers to Frame 62: 1. 1. D 2. B 3. A 4. C 5. D
2. 1. C 2. A 3. D 4. B

Frame 64



The thickness gauge consists of a set of leaves of hard steel. Each leaf is ground to a definite thickness, having one end of each leaf fastened into a protective case. A set usually consists of leaves ranging in size from fifteen ten-thousandths (0.0015) of an inch to twenty-five thousandths (0.025) of an inch.

Thickness gauges are used to measure the clearance between two parts. One leaf at a time is tried until the thickness leaf which will enter the opening is found. The clearance is determined by reading the thickness stamped on the particular leaf.

The leaf should always be wiped off before trying to insert it between two parts. The leaf should never be forced into an opening. Light pressure only should be applied. If the leaf is forced, it may spread the opening. This gives an inaccurate indication of size or there is danger of kinking the leaf and ruining it. Two leaves may be wiped clean and used together if one leaf of the proper thickness is not available.

Check (✓) the correct statement(s) below.

____ 1. The thickness gauge is calibrated in thousandths of an inch.

____ 2. Thickness gauges are used to measure the clearance between two parts.

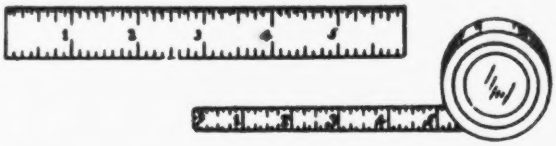
____ 3. Only one leaf of the thickness gauge can be used to measure the clearance.

Answers to Frame 63:

Question No	Answer	Review Frame	Question No	Answer	Review Frame
1.	D	43	10.	B	43
2.	A	44	11.	C	45
3.	B	47	12.	B	45
4.	C	48	13.	B	48
5.	A	50	14.	D	50
6.	B	51	15.	C	51
7.	B	54	16.	A	54
8.	C	60	17.	B	55
9.	C	41	18.	C	59

Frame 65

The work of a mechanic is no more accurate than the measurements he makes. It is important, therefore, that he learns to use and read measuring instruments correctly and accurately. There are many different types of measuring instruments; each type is best for a specific purpose. The most common unit of measurement with which you will work is the inch, which is further divided into fractions.



Rules are usually made of steel and they are available in 4, 6, or 12-inch lengths. The largest unit of measurement common to these rules is the inch. The inch may be divided into smaller fractions, such as 1/4, 1/2, 1/8, 1/16, 1/32, and even 1/64. Graduations of less than 1/64 are not used because they are difficult to read.

Tapes are available in many kinds and lengths. The one commonly used by most mechanics is six feet in length and is made of flexible steel. It is coiled in a circular case. The tape may be easily drawn out of its case when needed, and pushed back into the case when not needed. Tapes are graduated, usually in sixteenths (1/16) or thirty-seconds (1/32) of an inch. Most tapes have a small lip on one end which prevents the end from slipping into the case when the tape is rolled up into the case. This lip also enables the user to line up the end of the tape more easily with the end of the piece being measured.

Check (✓) the correct statement(s) below.

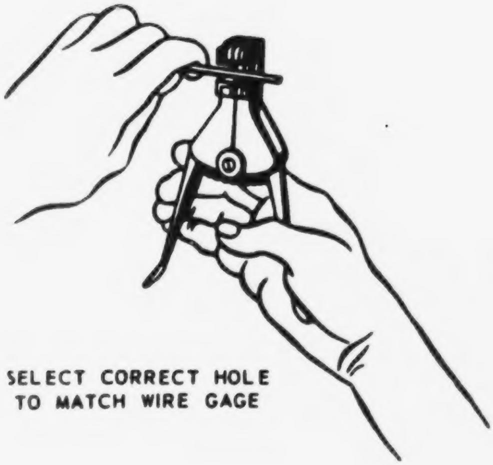
____ 1. The smallest measurement on a rule is 1/32 of an inch.

____ 2. Tapes are used when long distance measurements are required.

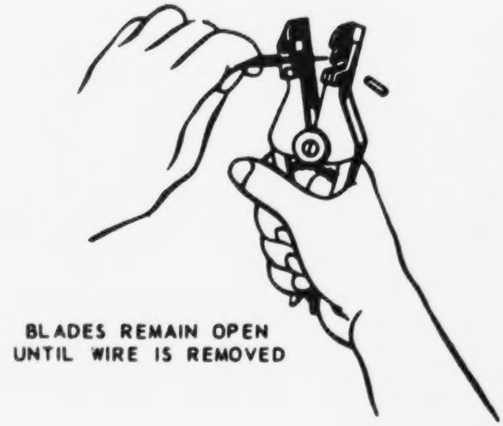
____ 3. To measure the diameter of a bolt, you would use a rule.

____ 4. To measure the length of a component, you would use a tape measure.

Answers to Frame 64: 1.__✓__ 2.__✓__ 3.____



SELECT CORRECT HOLE
TO MATCH WIRE GAGE



BLADES REMAIN OPEN
UNTIL WIRE IS REMOVED

Wire strippers are used to take off insulation from the ends of electrical wires. Several holes corresponding to various wire sizes are in the cutting edge of the tool. Care must be taken to make sure that the correct hole is used for the wire being stripped. If the stripper hole is too small, some wire strands may be cut.

Check (✓) the true statement(s) below.

____ 1. There must be careful selection of the hole on the wire stripper for the wire size to be stripped.

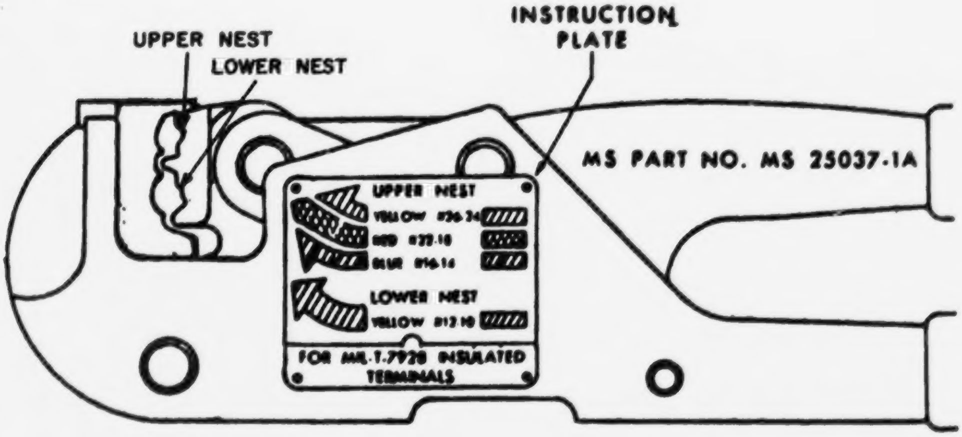
____ 2. The stripper should cut completely through the insulation.

____ 3. A stripper is a handy tool for removing insulation from the center of a length of wire.

Answers to Frame 65: 1.____ 2.__✓__ 3.__✓__ 4.__✓__

Frame 67

The crimping tool, shown below, should be used for connecting (crimping) preinsulated terminals to conductors. Other crimping tools such as Stakon pliers should be used to crimp noninsulated terminals. The insulation on the terminals is color coded according to the size of the conductors to which they are to be joined. The instruction plate on the tool shows which of the nests should be used for the sizes of wire.


INSTRUCTION PLATE
UPPER NEST
LOWER NEST
MS PART NO. MS 25037-1A
UPPER NEST
YELLOW #26-24
RED #22-18
BLUE #16-14
LOWER NEST
YELLOW #12-10
FOR MIL-T-7928 INSULATED TERMINALS

Check (✓) the true statement(s) below.

____ 1. Preinsulated terminals can be crimped to a conductor.

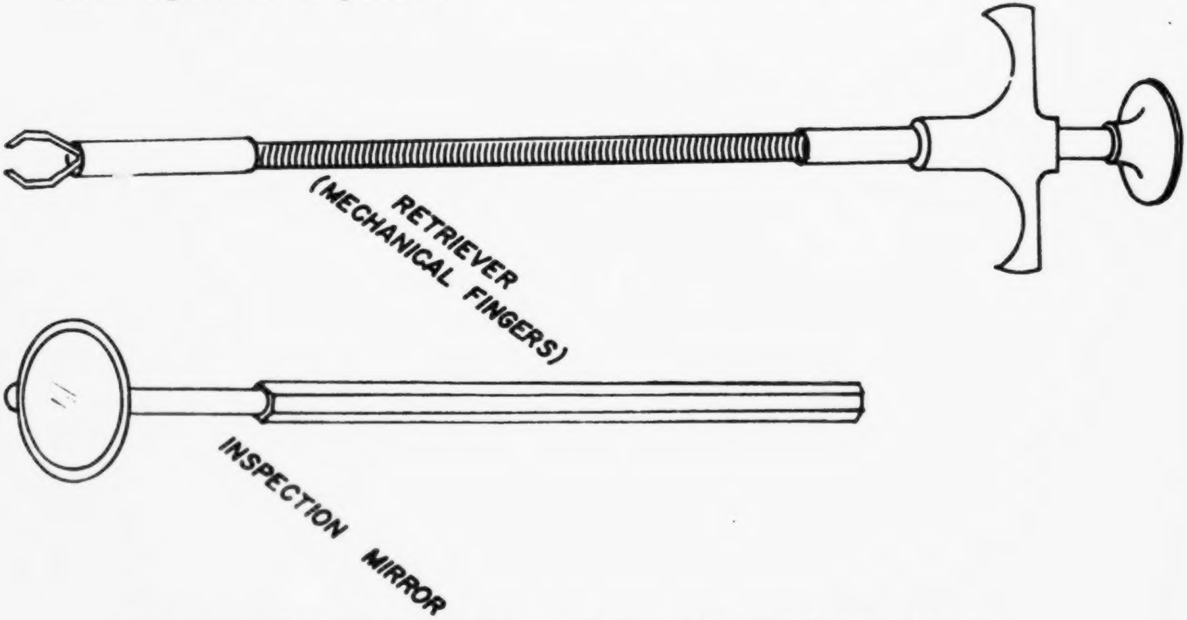
____ 2. Noninsulated terminals can be crimped to a conductor.

____ 3. The instruction plate on the crimper indicates the pressure needed to crimp terminals to wires.

Answers to Frame 66: 1.__✓__ 2.__✓__ 3.____

Frame 68

The retriever, sometimes called "mechanical fingers," is used to pick up small objects that are located in inaccessible areas. By pushing down the button, the grip opens enabling small objects to be grabbed.



An inspection mirror can be used when the work being done is located in such a position that it is out of view. A noninsulated mirror should not be used around live electrical circuits.

1. Check (✓) the correct statement(s) below.

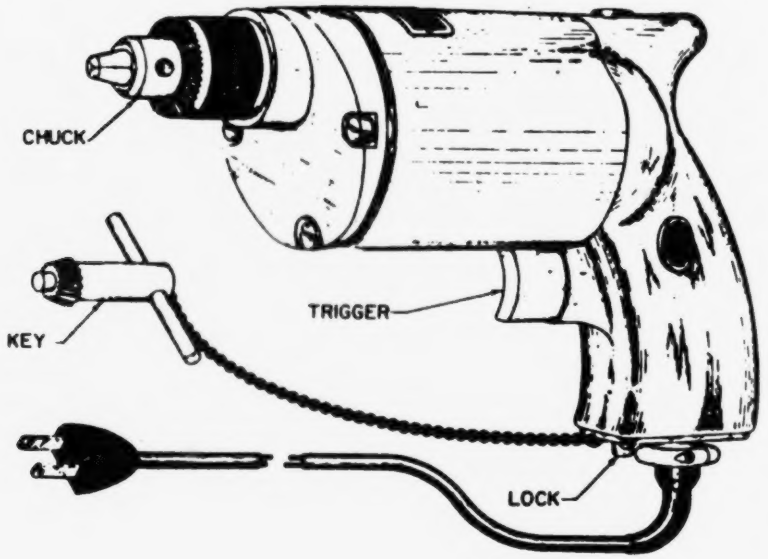
____ 1. The retriever can be used to pick up fallen screws in hard-to-get-at places.

____ 2. An insulated inspection mirror must be used on all equipment.

Answers to Frame 67: 1.__✓__ 2.__✓__ 3.____

Frame 69

One of the most useful tools available to the mechanic is the electric drill. The principal use of the electric drill is for boring or drilling holes in metal. Drills commonly used in the shop are of the 1/4-inch, 3/8-inch, or 1/2-inch capacity. It is never advisable to exceed the rated capacity of an electric drill. Such a practice usually results in burning up the drill motor. For shop use, hardened steel drill bits are used with the electric drill. As you can see from the picture below, the main parts of the portable electric drill are the motor, chuck, handle, trigger, trigger lock, and chuck key.



Circle the letter of the correct statement below.

a. The best tool for drilling holes in metal is the electric drill.

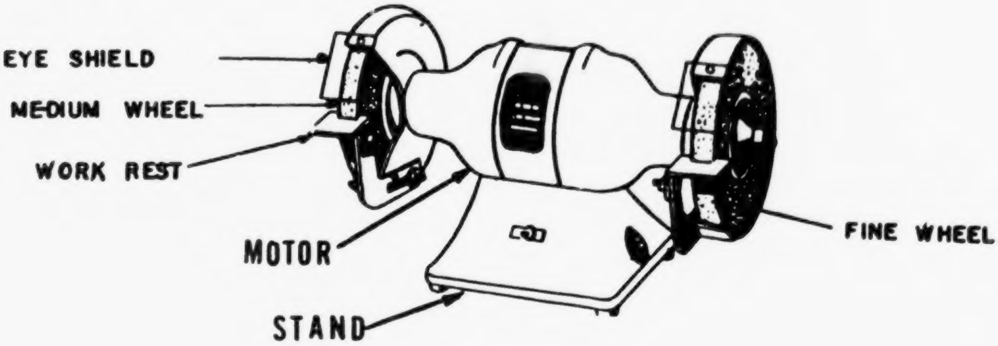
b. The capacity of an electric drill should never be exceeded.

c. Hardened steel drill bits are best for use with the electric drill.

d. All of the above statements are true.

Answers to Frame 68: 1. 1._✓_ 2.____

Another power tool found in most shops is the bench grinder. A typical bench grinder is shown in the illustration below. Note that the main parts of the bench grinder are the stand, motor, grinding wheels, work rest, and eye shield. The grinding wheels should always be checked for cracks before starting the motor.



The bench grinder works best at maximum RPM. Too much pressure on the grinding wheel will cause the motor to overheat and the metal being sharpened to burn. The grinding action is the result of friction between the wheel and the metal; so the faster the rotation of the grinding wheel, the greater the friction.

Circle the letter in front of the correct statement below.

a. Pressing hard on the grinding wheel increases its efficiency.

b. Too much pressure on the wheel will cause the metal to burn.

c. If the motor turns too fast, it will overheat.

d. Friction helps cool the metal.

Answer to Frame 69: d

Frame 71

The bench grinder usually has two stones or wheels; one made of fine grit and the other of coarse grit. The grit is held together by a strong adhesive. An electric motor (usually rated at 1/2 horsepower) turns the stones at a high rate of speed. The material to be sharpened, smoothed, or reduced in size is held on the tool rest and pressed against the rotating stone.

Circle the letter in front of the correct statement(s) below.

a. Grinding wheels are cut out of solid stone.

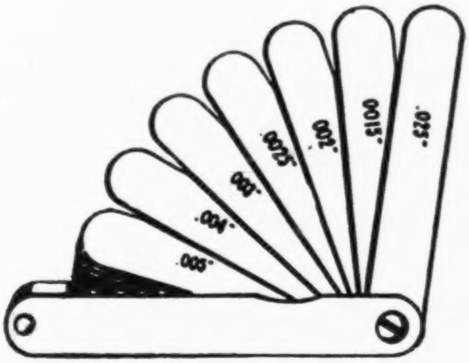
b. Bench grinders are used to sharpen chisels, punches, and drill bits.

c. The material to be "ground" is pressed against the rotating wheel.

d. The stones are turned at a high rate of speed.

Answer to Frame 70: b

Answer the following questions concerning tools. If you missed any questions, review the appropriate frames.



1. The above tool is called a

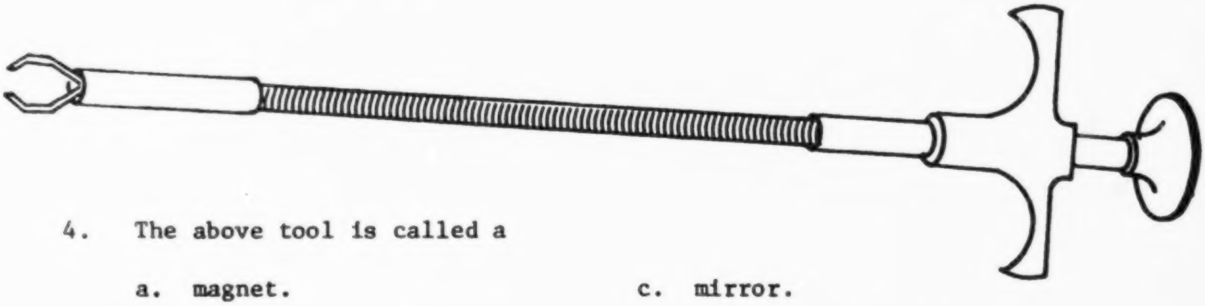
    a. rule.
    b. tape measure.
    c. thickness gage.
    d. depth gage.

2. The tool best suited to measure the diameter of a bolt is called a

    a. rule.
    b. tape measure.
    c. thickness gage.
    d. yard stick.

3. To remove the insulation from a wire you would best use a

    a. crimping tool.
    b. knife.
    c. wire stripper.
    d. diagonal cutting pliers.



4. The above tool is called a

    a. magnet.
    b. retriever.
    c. mirror.
    d. long stem screwdriver.

Frame 72 Continued

5. The drill bit on an electric drill is inserted in the

   a. mouth.
   b. chuck.
   c. nose.
   d. lock.

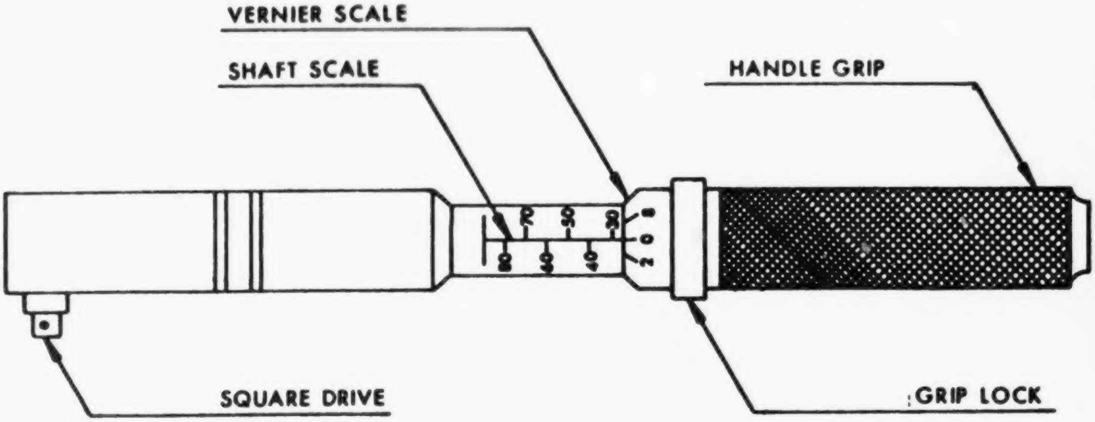
6. A bench grinder operates most efficiently

   a. at maximum RPM.
   b. at slow speeds.
   c. without a tool rest.
   d. when pressing hard on the grinding wheel.

Check (✓) your answers at the end of frame 85. If you missed any of the questions, review the appropriate frames before going on to the next frame.

Answers to Frame 71: b c d

A torque wrench is used to measure how much torque (twisting force) is applied to a nut when it is put on a bolt. Some wrenches are made to measure torque in inch-pounds, others in foot-pounds. The type of torque wrench most used in the Air Force is the "breakaway" type. These are sometimes called the Automatic-Release-Torque wrench. This is the only type of wrench we are authorized to use on nuts, bolts, etc., which we put on a plane. The breakaway torque wrench (see sketch below) has a square drive, shaft scale, vernier scale, grip on handle and a grip lock.



Check the correct statement(s) below.

_____1. Torque wrenches measure torque in foot-pounds only.

_____2. The "breakaway" type torque wrench is the most commonly used torque wrench in the Air Force.

_____3. The Vernier scale and the grip lock are attached to the handle.

_____4. Common aircraft hardware should NOT be torque with a "breakaway" type torque wrench.

Frame 74

Some types of torque wrenches are the screwdriver type, the flexible beam type and the dial which are NOT authorized for use in tightening common aircraft hardware. In some specific applications of checking torque, an aircraft manual or equipment maintenance manual may require one of the above mentioned wrenches to be used.

Note: The term "TORQUE WRENCH" in portions of this text may be shortened to "wrench."

Check (✓) the correct statement(s) below.

_____1. Any type of torque wrench is authorized for use on common aircraft hardware.

_____2. The flexible beam type torque wrench should not be used to torque a nut on an aircraft.

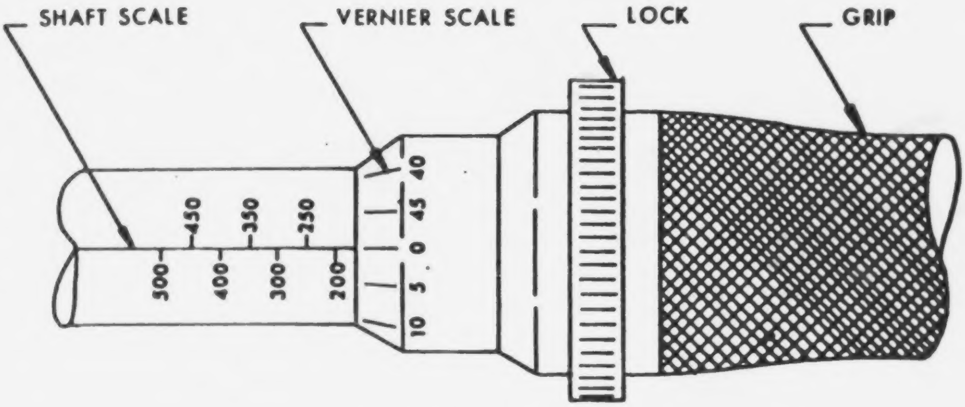
_____3. An aircraft technical manual will never list a type of torque wrench other than the authorized "breakaway" type.

_____4. An equipment maintenance manual may require a dial type torque wrench to be used.

Answers to Frame 73; _____1. __✓__2. __✓__3. _____4.

Frame 75

The breakaway torque wrench may be adjusted. The torque value you want for the unit you are to work on can be set (within limits of the torque wrench) by turning the handle (grip) to settings on the micrometer type scale. The micrometer type scale is made up of the shaft scale, on the bar part of the wrench, and the vernier scale on the handle. In the sketch below, note the shaft scale is graduated in 50 inch-pounds. The vernier scale is graduated from 0 to 50 inch-pounds which will let us change the torque setting to what is called for in the technical order.



Note: For a foot-pound torque wrench the graduation would be in foot-pounds.

Check (✓) the correct statement(s) below.

_____1. Breakaway torque wrenches are not adjustable.

_____2. The micrometer (the shaft scale and the vernier scale) is used to indicate the amount of torque set on the wrench.

_____3. The shaft scale is graduated in 50 inch-pounds.

_____4. One complete turn of the handle will give an increase or decrease of 50 inch-pounds.

Answers to Frame 74: _____1. _____2. __✓__3. __✓__4.

Frame 76

The unit you must install has a higher torque value on the nuts then you have set on the wrench. To reach this new torque value the handle (grip) must be turned to the right which will add tension to the spring in the handle. This will also make the handle shorter in length and change the reading on the micrometer type scale. If you need a lower torque, then turn the handle to the left until you pass your desired setting. You should always approach the setting you want on the wrench from the lower end of the scale.

Check the correct statement(s) below.

_____1. To change the torque value on the wrench, the handle (grip) must be turned.

_____2. A torque setting is approached from the higher end of the scale.

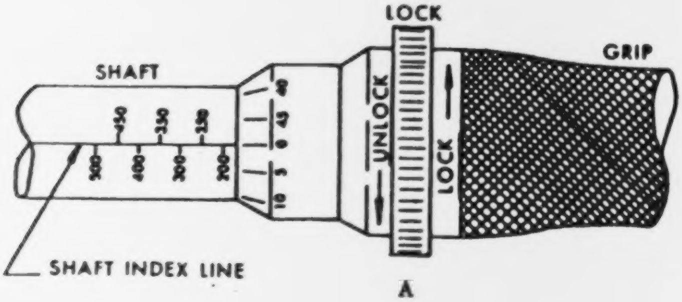
_____3. To increase the torque setting, the handle is turned counterclockwise.

_____4. Turning the handle reduces or increases tension on the spring inside the handle.

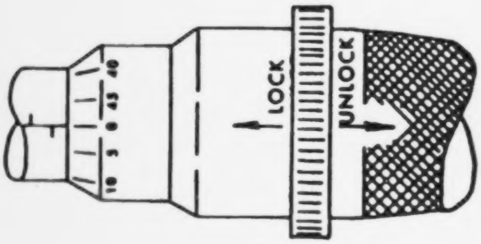
Answers to Frame 75: _____1. __✓__2. __✓__3. __✓__4.

Frame 77

The breakaway torque wrench has a lock to make sure that the torque value you set does not change when you use the wrench. On some of the wrenches the lock is turned (figure A) to engage and lock the handle. In other wrenches the locking is done by sliding the lock along the handle to engage a pawl or slot in the shaft (figure B). In either case, the grip is kept from turning when the wrench is in use. The lock must be "UNLOCKED" before the handle (GRIP) can be turned. The lock can only be "locked" when a number on the vernier scale (0, 5, 10, etc) is in line with the "SHAFT INDEX LINE" (see sketch below).


LOCK
SHAFT
GRIP
450
350
250
500
400
300
200
40
45
0
5
10
UNLOCK
LOCK
SHAFT INDEX LINE

A


40
45
0
5
10
LOCK
UNLOCK

B

Check (✓) the correct statements below.

_____1. The breakaway torque wrench has a locking device.

_____2. The handle (grip) cannot be turned when the lock is "unlocked."

_____3. A number on the vernier scale must be in line with the "shaft index line" before the locking device will "lock."

Answers to Frame 76: __✓__1. _____2. _____3. __✓__4.

Frame 78

The torque wrench will automatically release or "break" when you reach a set amount of torque on a nut or bolt. When the handle releases, it will have approximately fifteen to twenty degrees of free travel and should not be pulled beyond this point.

Check (✓) the correct statement(s) below.

_____1. The handle should be pulled after it releases or "breaks."

_____2. When the handle releases or breaks the desired amount of torque has been applied.

_____3. After fifteen or twenty degrees of free travel, the handle should not be pulled beyond this point.

Answers to Frame 77: ✓ 1. _____2. ✓ 3. _____4.

Frame 79

Identify the parts of the torque wrench on the illustrated diagram below by selecting the names from the list and writing the names in the appropriate numbered spaces on the illustration.

NAMES

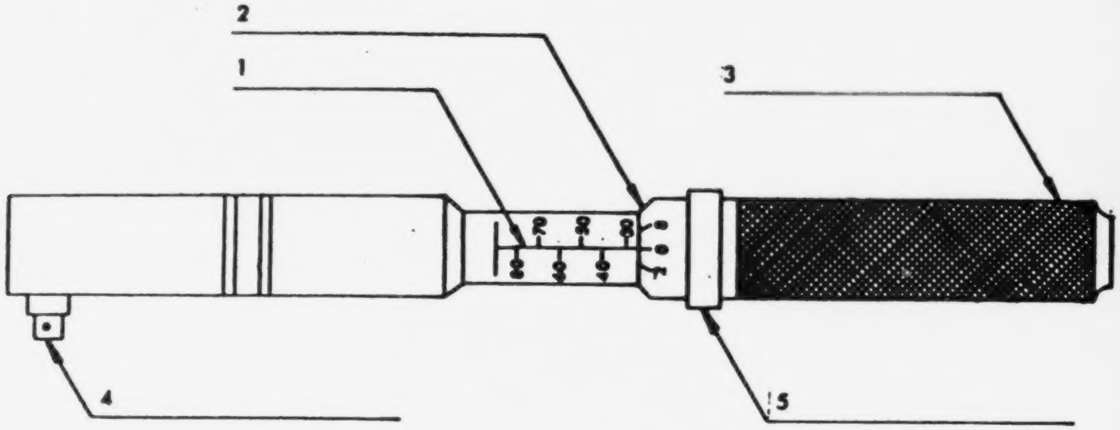
Grip Lock

Shaft Scale

Handle (Grip)

Socket Drive

Vernier Scale



Answers to Frame 78: _____ 1. ✓ 2. ✓ 3.

Frame 80

From time to time as you use torque wrenches you may have to change inch-pounds to foot-pounds. Divide the inch-pound figure by 12 (the number of inches in a foot) to change from inch-pounds to foot-pounds. For example: 600 inch-pounds divided by 12 equals 50 foot-pounds. To change foot-pounds to inch-pounds, multiply the figure, Ex: 10 ft by 12 (number of inches in 1 ft) thus you have 10 ft by 12 in = 120 inch-pounds.

Check (√) the correct statement(s) below.

_____1. To change inch-pounds to foot-pounds divide the foot-pounds by 12.

_____2. To change foot-pounds to inch-pounds multiply the foot-pounds by 12.

_____3. Twelve (12) foot-pounds is equal to one (1) inch-pound.

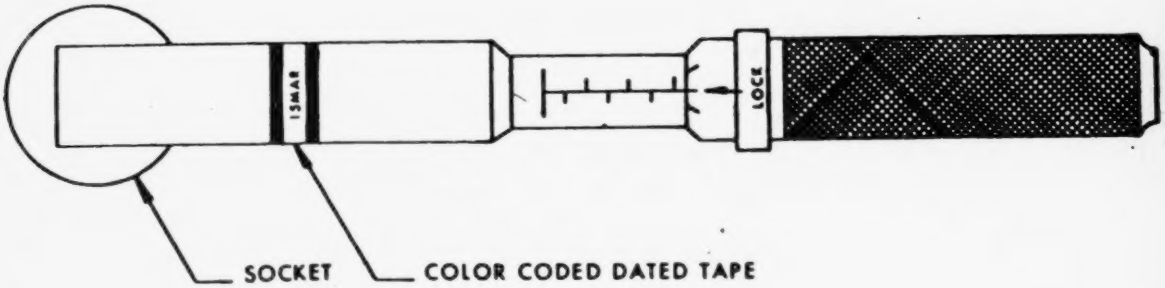
_____4. Forty-eight (48) inch-pounds is equal to four (4) foot-pounds.

Answers to Frame 79: 1. Shaft Scale 2. Vernier Scale 3. Handle
4. Socket Drive 5. Grip Lock

Frame 81

Torque wrenches are issued from supply to the shops or tool cribs for use when you work on planes and other critical equipment which will be verified at least once every two months (60 days). We calculate the 60 calendar days from the date of verification (see note below). For example, a wrench verified on 15 Jan 77 will be due reverification on 15 Mar 77.

> Note: Verification - a check operation to determine accuracy or inaccuracy of a torque wrench, using a suitable torque wrench tester. Calibration - actual adjustment necessary to bring a torque wrench into acceptable tolerances.



Check (✓) the correct statement(s) below.

_____1. Torque wrenches in the shops or tool cribs shall be verified at least once every two months (60 days).

_____2. A color coded dated tape is fastened to the torque wrench during verification.

_____3. A torque wrench will always be calibrated before it is verified.

Answers to Frame 80: _____1. __✓__2. _____3. __✓__4.

Frame 82

The following colors of tapes will be used to indicate the month the torque wrench is due verification:

Colors	Months
Blue	January-May-September
Red	February-June-October
Black	March-July-November
Yellow	April-August-December

Note: If a torque tool is dropped or otherwise abused, it will be verified and if necessary, calibrated prior to further use.

Check (✓) the correct statement(s) below.

_____1. The coded tapes will indicate the day, month and year the torque wrench was verified.

_____2. By looking at the date and color coded tape, one can determine when the torque wrench is due verification.

_____3. Each color coded tape represents three different months.

Answers to Frame 81: _____1. __✓__2. _____3.

Torque wrenches are precision measuring instruments. These must be handled with care and not treated like some people who just throw their hand tools in a box. After use, you should turn the grip to the full counterclockwise position to take the tension off the spring in the handle (frame 75). If the spring is under tension all of the time, it may change the strength of the spring. The accuracy of the spring tension determines the accuracy of the wrench. You should set the wrench at its lowest setting and then store it in its own storage container.

Check (✓) the correct statement(s) below.

_____1. Torque wrenches are precision measuring instruments.

_____2. Torque wrenches are stored at their highest setting.

_____3. Torque wrenches are stored in tool boxes.

_____4. Torque wrenches are stored at their lowest setting in storage containers.

Answers to Frame 82: _____1. __✓__2. __✓__3.

Frame 84

The following are a few precautions to observe concerning torque wrenches:

1. An extension shall not be used on the grip end of the handle.

2. Torque wrenches shall not be used to break loose previously tightened bolts.

3. A torque wrench shall not be used to apply a greater amount of torque than the rated capacity of the wrench.

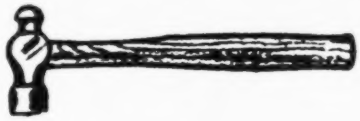
4. Do not attempt to change setting when the handle is in the locked position.

5. Do not place an extension on the square drive that increases the length of the torque wrench without mathematically calculating the torque value to set on the handle.

NO RESPONSE REQUIRED

Answers to Frame 83: _✓_ 1. ___ 2. ___ 3. _✓_ 4.

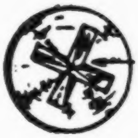
Now that you have completed the programmed text on handtools, let's review some of the information covered prior to taking the test. Answer the following questions concerning the identification and use of handtools by circling the correct response.



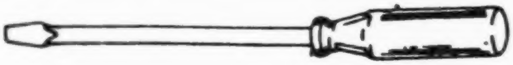
1. The above handtool is called a
   - a. mallet.
   - b. sledge hammer.
   - c. plastic hammer.
   - d. ball peen hammer.

2. What type of hammer is frequently used to expand the end of a rivet in a hole?
   - a. Mallet.
   - b. Sledge hammer.
   - c. Ball peen hammer.
   - d. Plastic hammer.

3. Most accidents with hammers are caused by
   - a. loose hammer heads.
   - b. sweaty hands.
   - c. greasy handles.
   - d. all of the above.

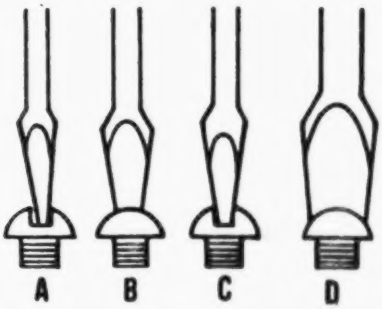


4. What type of screwdriver is used for the above screw head?
   - a. Clutchhead screwdriver.
   - b. Crosspoint screwdriver.
   - c. Common screwdriver.
   - d. Offset flat tip screwdriver.

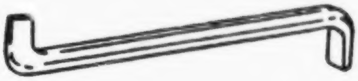


5. What type of screwdriver is pictured above?
   - a. Offset screwdriver.
   - b. Phillips screwdriver.
   - c. Prince and Reed screwdriver.
   - d. Flat tip screwdriver.

6. The size of a screwdriver is determined by
    a. the size of the blade.
    b. the size of the handle.
    c. the length of the screwdriver.
    d. the combined length of the blade and the shank.

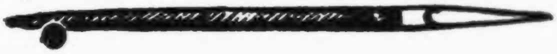


7. Which of the above illustrations shows the correct size of screwdriver to be used?
    a. A and B.
    b. A and D.
    c. C and D.
    d. B and C.



8. What tool is pictured above?
    a. Flat tip screwdriver.
    b. Cross tip screwdriver.
    c. Cross tip offset screwdriver.
    d. Offset flat tip screwdriver.

9. The part of the file used when filing is called the
    a. file heel.
    b. file face.
    c. file tang.
    d. file point.



10. The above pictured file is called a
    a. half-round file.
    b. rattail file.
    c. taper file.
    d. flat file.

11. Rows of teeth on a file that criss-cross each other are called a

    a. bastard grade file. c. single-cut file.

    b. smooth grade file. d. double-cut file.

12. A file is properly used when

    a. only slight pressure is applied on the forward stroke.

    b. even pressure is applied on both, the forward and backward strokes.

    c. a smooth, firm, forward stroke is used.

    d. a lot of pressure is applied on the forward stroke, slight pressure is applied on the return stroke.

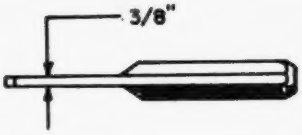
13. The tooth-points on a hacksaw blade must

    a. be coarse enough to straddle the work.

    b. be very small in order to clean the chips away.

    c. face backward, towards the handle.

    d. face forward, towards the tip of the saw.



14. The above chisel is called a

    a. cape chisel. c. diamond point chisel.

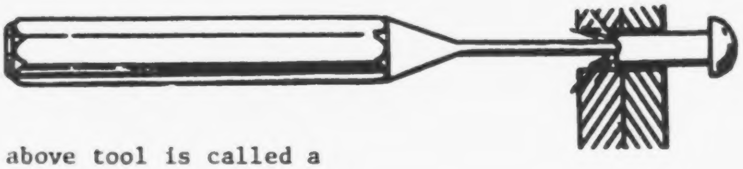
    b. cold chisel. d. drift chisel.

15. To cut a "V" groove in metal, you use a

    a. diamond point chisel. c. flat chisel.

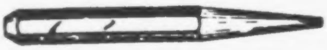
    b. chassis chisel. d. hacksaw.

Frame 85 (Continued)



16. The above tool is called a

a. drift punch.
b. pin punch.
c. center punch.
d. chassis punch.



17. The above tool is called a

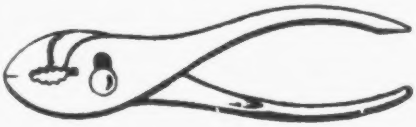
a. drift punch.
b. pin punch.
c. center punch.
d. chassis punch.

18. To mark the locations of holes to be drilled, you use a

a. pin punch.
b. drift punch.
c. center punch.
d. chassis punch.

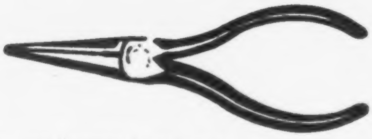
19. Chisels and punches that have become mushroomed should be

a. used.
b. thrown away.
c. turned in for a new one.
d. dressed on a grinding wheel.



20. The above pliers are referred to as

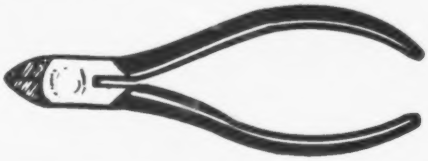
a. combination pliers.
b. wrench pliers.
c. water pump pliers.
d. conduit pliers.



21. The above pliers are referred to as

a. duckbill pliers. c. combination pliers.

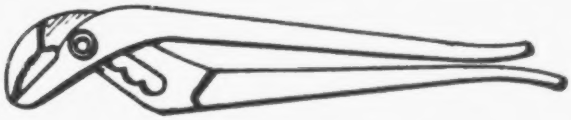
b. needle-nose pliers. d. conduit pliers.



22. The above pliers are often referred to as

a. vise grips. c. dykes.

b. wrench pliers. d. combination pliers.



23. The above pliers are often referred to as

a. conduit pliers. c. water pump pliers.

b. cannon plug pliers. d. wrench pliers.

24. Combination pliers are commonly used to

a. turn a nut. c. tighten a bolt.

b. cut a wire. d. bend a piece of metal.

25. To form loops in electrical wire, you would use

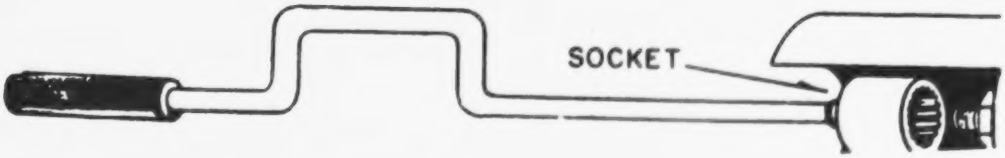
a. duckbill pliers. c. wrench pliers.

b. dykes. d. needle-nose pliers.

26. To loosen a cannon plug, you would best use

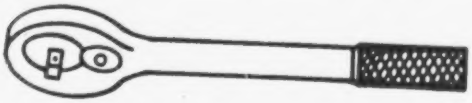
a. water pump pliers. c. wrench pliers.

b. conduit pliers. d. combination pliers.



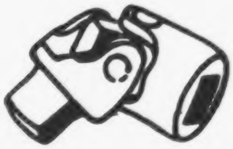
27. The above tool is called a

    a. hinge handle.
    b. ratchet handle.
    c. "T" handle.
    d. speed handle.



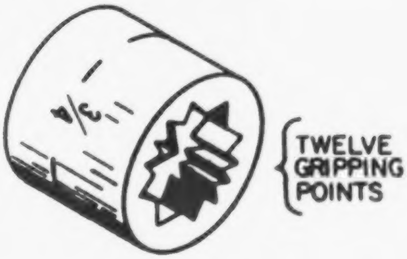
28. The above tool is called a

    a. hinge handle.
    b. ratchet handle.
    c. "T" handle.
    d. speed handle.



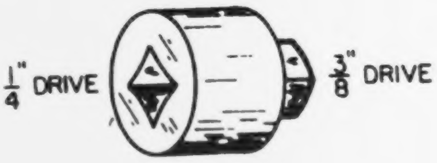
29. The above tool is called a(n)

    a. extension.
    b. swivel socket.
    c. universal joint.
    d. shallow socket.



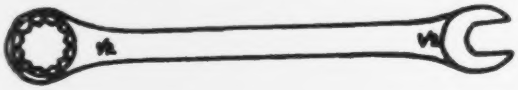
30. The above socket will fit a

    a. 3/4" drive.
    b. 3/4" bolthead.
    c. any size bolthead.
    d. 3/4" drive and 3/4" bolthead.



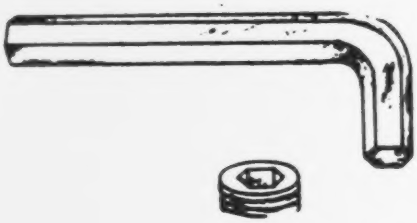
31. The above tool is called a(n)

    a. universal joint.
    b. adapter.
    c. socket.
    d. spark plug socket.



32. The above tool is called a(n)

    a. open-end wrench.
    b. box-end wrench.
    c. combination wrench.
    d. adjustable wrench.



33. The above tool is sometimes called a(n)

    a. external wrench.
    b. socket wrench.
    c. box-end wrench.
    d. Allen wrench.

34. The best tools for removing nuts and bolts wherever possible are

    a. adjustable jaw wrenches.
    b. combination pliers.
    c. socket wrenches.
    d. open-end wrenches.

35. Which socket handle can be operated without having to raise the socket off the nut for another "bite"?

    a. Hinge handle.
    b. Ratchet handle.
    c. Speed handle.
    d. "T" handle.

36. To get to a nut that is located in a hard-to-get-at place, you would use a(n)

    a. adapter.
    b. universal joint.
    c. "T" handle.
    d. speed handle.

37. To reduce the total number of tools required to be carried to a job, you would be best to carry a(n)

    a. universal joint.
    b. speed handle.
    c. adapter.
    d. extension.

38. Which one of the following tools is best suited to remove a nut?

    a. Box-end wrench.
    b. Open-end wrench.
    c. Adjustable jaw wrench.
    d. Pliers.

39. Which one of the following wrenches will yield the largest amount of torque?

    a. Short-handled open-end wrench.
    b. Long-handled box-end wrench.
    c. Adjustable jaw wrench.
    d. Short-handled box-end wrench.

40. What is the correct way to use an adjustable jaw wrench?

    a. Push it toward the adjustable jaw.
    b. Push it toward the stationary jaw.
    c. Pull it toward the adjustable jaw.
    d. Pull it toward the stationary jaw.

41. To measure the clearance on a spark plug gap, you would best use a

a. rule.
b. thickness gauge.
c. tape measure.
d. depth gage.

42. To connect preinsulated terminals to conductors, you would best use

a. wire strippers.
b. a knife.
c. a crimping tool.
d. Stakon pliers.

43. The drill bit on an electric drill is inserted in the

a. mouth.
b. chuck.
c. nose.
d. lock.

44. The automatic-release torque wrench is referred to as the

a. flexible beam type torque wrench.
b. dial type torque wrench.
c. screwdriver type torque wrench.
d. breakaway type torque wrench.

45. 600 inch-pounds is equal to

a. 50 foot-pounds.
b. 30 foot-pounds.
c. 10 foot-pounds.
d. 5 foot-pounds.

46. Color coded tapes on torque wrenches indicate

a. the torque value of the wrench.
b. the last calibration date.
c. the due date of verification.
d. the due date of calibration.

Answers to Frame 72

Question No	Answer	Review Frame
1.	c	64
2.	a	65
3.	c	66
4.	b	68
5.	b	69
6.	a	70

Answers to Frame 85

Question No	Answer	Review Frame
1.	d	2
2.	c	4
3.	d	7
4.	b	10
5.	d	9
6.	d	9
7.	c	13
8.	d	12
9.	b	15
10.	b	16
11.	d	17
12.	c	19
13.	d	23
14.	a	25
15.	a	26
16.	b	28
17.	a	28
18.	c	29
19.	d	27
20.	a	32
21.	b	33
22.	c	35
23.	c	36
24.	d	32
25.	d	33
26.	b	37
27.	d	43
28.	b	45
29.	c	48
30.	b	50
31.	b	51
32.	c	57
33.	d	60
34.	c	41
35.	b	45
36.	b	48
37.	c	51
38.	a	54
39.	b	55
40.	c	59
41.	b	64
42.	c	67
43.	b	69
44.	d	73
45.	a	80
46.	c	81

RESPONSE SHEET

Section I

Frame 1

No Response Required

Frame 2

_____ 1.

_____ 2.

Frame 3

_____ 1.

_____ 2.

_____ 3.

Frame 4

_____ 1.

_____ 2.

_____ 3.

Frame 5

1. 1. _____

2. _____

3. _____

Frame 6

1. a. _____

2. _____ a.

_____ b.

_____ c.

Frame 7

_____ 1.

_____ 2.

_____ 3.

Frame 8

_____ 1.

_____ 2.

_____ 3.

_____ 4.

Frame 9

1. _____ 1.

_____ 2.

_____ 3.

_____ 4.

Frame 10

_____ 1.

_____ 2.

_____ 3.

_____ 4.

Frame 11

1. _____ 1.

_____ 2.

_____ 3.

Frame 12

1. _____ 1.

_____ 2.

_____ 3.

Frame 13

_____ 1.

_____ 2

Frame 13 Cont'd

_____ 3.

_____ 4.

Frame 14

1. a, b, c, d.

2. a, b, c, d.

3. a, b, c, d.

4. a, b, c, d.

5. a, b, c, d.

6. a, b, c, d.

7. a, b, c, d.

8. a, b, c, d.

9. a, b, c, d.

10. a, b, c, d.

11. a, b, c, d.

12. a, b, c, d.

Section II

Frame 15

_____ 1.

_____ 2.

_____ 3.

_____ 4.

_____ 5.

RESPONSE SHEET

Section II Cont'd

Frame 16

1. ______ 1.
______ 2.
______ 3.
______ 4.
2. ______ 1.
______ 2.
______ 3.
______ 4.

Frame 17

______ 1.
______ 2.
______ 3.
______ 4.

Frame 18

______ 1.
______ 2.
______ 3.

Frame 19

1. ______ 1.
______ 2.
______ 3.
______ 4.
2. ______ 1.
______ 2.

Frame 20

1. ______ 1.
______ 2.

Frame 21

1. ______ 1.
______ 2.
______ 3.

Frame 22

1. ______ 1.
______ 2.
______ 3.

Frame 23

______ 1.
______ 2.
______ 3.
______ 4.

Frame 24

______ 1.
______ 2.
______ 3

Frame 25

1. ______ 1
______ 2
______ 3.

Frame 26

______ 1.
______ 2.
______ 3.

Frame 27

1. ______ 1.
2. ______ 1.
______ 2.
______ 3.

Frame 28

1. ______ 1.
______ 2.
______ 3.

Frame 29

1. ______ 1.
______ 2.
______ 3.
2. ______ 1.
______ 2.
______ 3.
______ 4.
______ 5.
______ 6.

RESPONSE SHEET

Section II Cont'd

Frame 30

1. a, b, c, d.
2. a, b, c, d.
3. a, b, c, d.
4. a, b, c, d.
5. a, b, c, d.
6. a, b, c, d.
7. a, b, c, d.
8. a, b, c, d.
9. a, b, c, d.
10. a, b, c, d.
11. a, b, c, d.
12. a, b, c, d.
13. a, b, c, d.
14. a, b, c, d.

Section III

Frame 31

No Response Required

Frame 32

_____ 1.
_____ 2.
_____ 3.

Frame 33

_____ 1.
_____ 2.

Frame 33 Cont'd

_____ 3.
_____ 4.

Frame 34

_____ 1.
_____ 2.
_____ 3.
_____ 4.

Frame 35

_____ 1.
_____ 2.
_____ 3.
_____ 4.
_____ 5.

Frame 36

_____ 1.
_____ 2.
_____ 3.

Frame 37

_____ 1.
_____ 2.
_____ 3.
_____ 4.

Frame 38

1. _____ 1.
_____ 2.
_____ 3.

Frame 39

_____ 1.
_____ 2.
_____ 3.

Frame 40

1. a, b, c, d.
2. a, b, c, d.
3. a, b, c, d.
4. a, b, c, d.
5. a, b, c, d.
6. a, b, c, d.
7. a, b, c, d.
8. a, b, c, d.
9. a, b, c, d.
10. a, b, c, d.

Section IV

Frame 41

_____ 1.
_____ 2.
_____ 3.

Frame 42

_____ 1.
_____ 2.

Frame 43

_____ 1.
_____ 2.

RESPONSE SHEET

Secction IV Cont'd

Frame 44

_____ 1.

_____ 2.

_____ 3.

Frame 45

_____ 1.

_____ 2.

_____ 3.

Frame 46

_____ 1.

_____ 2.

_____ 3.

Frame 47

_____ 1.

_____ 2.

Frame 48

_____ 1.

_____ 2.

_____ 3.

Frame 49

1. _____ 1.

_____ 2.

_____ 3.

_____ 4.

Frame 49 Cont'd

_____ 5.

_____ 6.

2. _____ 1.

_____ 2.

_____ 3.

_____ 4.

_____ 5.

_____ 6.

Frame 50

_____ 1.

_____ 2.

_____ 3.

_____ 4.

_____ 5.

_____ 6.

Frame 51

_____ 1.

_____ 2.

_____ 3.

_____ 4.

Frame 52

_____ 1.

_____ 2.

Frame 53

1. _____ 1.

_____ 2.

_____ 3.

_____ 4.

_____ 5.

_____ 6.

___ ___ ___ 7.

_____ 8.

_____ 9.

_____ 10.

_____ 11.

_____ 12.

2. _____ 1.

_____ 2.

_____ 3.

_____ 4.

_____ 5.

Frame 54

_____ 1.

_____ 2.

_____ 3.

RESPONSE SHEET [illegible]

Section IV Cont'd

Frame 55

_____ 1.

_____ 2.

_____ 3.

_____ 4.

_____ 5.

Frame 56

_____ 1.

_____ 2.

_____ 3.

Frame 57

_____ 1.

_____ 2.

Frame 58

_____ 1.

_____ 2.

_____ 3.

Frame 59

_____ 1.

_____ 2.

_____ 3.

Frame 60

_____ 1.

_____ 2.

_____ 3.

Frame 61

_____ 1.

_____ 2.

_____ 3.

Frame 62

1. _____ 1.

_____ 2.

_____ 3.

_____ 4.

_____ 5.

2. _____ 1.

_____ 2.

_____ 3.

_____ 4.

Frame 63

1. a, b, c, d.

2. a, b, c, d.

3. a, b, c, d.

4. a, b, c, d.

5. a, b, c, d.

6. a, b, c, d.

7. a, b, c, d.

8. a, b, c, d.

9. a, b, c, d.

10. a, b, c, d.

Frame 63 Cont'd

11. a, b, c, d.

12. a, b, c, d.

13. a, b, c, d.

14. a, b, c, d.

15. a, b, c, d.

16. a, b, c, d.

17. a, b, c, d.

18. a, b, c, d.

Section V

Frame 64

_____ 1.

_____ 2.

_____ 3.

Frame 65

_____ 1.

_____ 2.

_____ 3.

_____ 4.

Frame 66

_____ 1.

_____ 2.

_____ 3.

Frame 67

_____ 1.

_____ 2.

_____ 3.

Section V Cont'd

Frame 68

1. _____ 1.

_____ 2.

Frame 69

a.

b.

c.

d.

Frame 70

a.

b.

c.

d.

Frame 71

a.

b.

c.

d.

Frame 72

1. a, b, c, d.
2. a, b, c, d.
3. a, b, c, d.
4. a, b, c, d.
5. a, b, c, d.
6. a, b, c, d.

Frame 73

1.___ 2.___ 3.___ 4.___

Frame 74

1.___ 2.___ 3.___ 4.___

Frame 75

1.___ 2.___ 3.___ 4.___

Frame 76

1.___ 2.___ 3.___ 4.___

Frame 77

1.___ 2.___ 3.___

Frame 78

1.___ 2.___ 3.___

Frame 79

1.____________________

2.____________________

3.____________________

4.____________________

5.____________________

Frame 80

1.___ 2.___ 3.___ 4.___

Frame 81

1.___ 2.___. 3.___

Frame 82

1. ___ 2. ___ 3. ___

Frame 83

1.___ 2.___ 3.___ 4.___

Section VI Frame 85

1. a, b, c, d.
2. a, b, c, d.
3. a, b, c, d.
4. a, b, c, d.
5. a, b, c, d,
6. a, b, c, d.
7. a, b, c, d.

Frame 85 Con't

8. a, b, c, d.
9. a, b, c, d.
10. a, b, c, d.
11. a, b, c, d.
12. a, b, c, d.
13. a, b, c, d.
14. a, b, c, d.
15. a, b, c, d.
16. a, b, c, d.
17. a, b, c, d.
18. a, b, c, d.
19. a, b, c, d.
20. a, b, c, d.
21. a, b, c, d.
22. a, b, c, d.
23. a, b, c, d.
24. a, b, c, d.
25. a, b, c, d.
26. a, b, c, d.
27. a, b, c, d.
28. a, b, c, d.
29. a, b, c, d.
30. a, b, c, d.
31. a, b, c, d.
32. a, b, c, d.
33. a, b, c, d.
34. a, b, c, d.
35. a, b, c, d.
36. a, b, c, d.
37. a, b, c, d.
38. a, b, c, d.
39. a, b, c, d.
40. a, b, c, d.
41. a, b, c, d.
42. a, b, c, d.
43. a, b, c, d.
44. a, b, c, d.
45. a, b, c, d.
46. a, b, c, d.

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Environmental Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-HO-303
27 October 1983

PURPOSE OF CONSOLIDATED TOOLKIT (CTK)

Dollars out of your pocket!!! Sounds drastic, dosen't it? Everyday throughout the military, thousands of dollars are wasted through foreign object damage (FOD). These initials - FOD - are probably new to you, but during your stay in the Air Force they will become familiar to you.

Foreign Object Damage is caused by a variety of things, mostly man-made. A mechanic installs a new engine bleed valve. During his installation he drops a 1/4" bolt (sounds pretty small, right?). In his haste to complete the job, he fails to check the area for FOD items. This small 1/4" bolt is eaten by the engine. Engines, you will find, have a big appetite; they will eat anything that can pass their inlet - bolts, nuts, safety wire, tools, rocks, even ear defenders and hats. The bolt, while being digested by the engine, nicks two compressors and three turbine blades. This damage does not become known until the pilot advances the throttles on takeoff. The turbine blades crack, causing the engine to be out of balance. The engine disintegrates, rupturing the fuel cells. Scratch one aircraft and eight people (four crew members and a family of four) as the aircraft crashes on a highway two miles from the runway. Although this is fictitious, incidents such as this have happened and will continue, unless we all practice good FOD prevention.

In dollars alone, we spend millions that need not be spent from damage caused by foreign objects. In 1976, SAC spent over a million dollars due to FOD. This includes damaged engines, tires, equipment and personal injuries.

We all complain about spending our money, especially when we have nothing to show for it. FOD is a major drain on your pocket. Being in the Air Force you tend to lose twice. How? First, your tax dollars must be used to remedy FOD; they must pay to replace or repair items damaged by FOD. Secondly, since the Defense budget is fixed (you get a set amount to operate on for one year), the more you spend needlessly, the less you have to operate on daily. As an example of this, if a B-52 tire is damaged by FOD, $280.00 is spent out of the Air Force budget. This is $280.00 less you'll have to spend on new equipment to make your job a little easier. It is really a needless expense, so practice good FOD prevention; it makes good sense!

While doing your projects, you will be required to practice FOD prevention. This means you will use care not to allow nuts, bolts, safety wire, etc., to be left in your work area when you complete your assigned job. Use the magnet provided to remove all traces of FOD.

Supersedes 3ABR42331-HO-402, 12 August 1980.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 150; DAV - 1

Designed for ATC Course Use. Do Not Use on the Job.

Clean up your project area. If your instructor finds FOD items during his inspection of your project, you will be required to reaccomplish the project. This is treated the same as a technical error and a failure will be entered in your progress record. Get used to it now, since it will become a part of your everyday life during your Air Force career.

While you are doing your projects, you will also use a consolidated toolkit (referred to as a CTK). The CTK program is one of many integral parts of the FOD program. This kit is a quick means of identifying lost or misplaced tools. They are made in many forms, such as bags, shadow boards, metal and wooden boxes. Some are even designed to fit into briefcases.

A CTK is one of these containers mentioned and is usually filled with strips of styrofoam or some type of spongy material. A silhouette of that tool is cut out and usually painted a specific color. The tools required to do the job are then placed in the container. This is done so that any shortage can instantly be identified.

If any shortage does occur, you can easily find the tool since you have not left the job. You must backtrack until you find the tool. This will prevent FOD and perhaps save thousands of dollars in FOD damage.

HANDOUT
C3ABR42331-HO-101

Technical Training

Aircraft Environmental Systems Mechanic

GLOSSARY OF TERMS

8 February 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: N/A

This handout is in four sections. Section I is a list of frequently used abbreviations. Section II is frequently used symbols. Section III is intended to give you general definitions that apply to several areas of study. Section IV (electrical terms) is more specific in that the terms apply to one main area of study. Anytime you are studying a piece of material that has words of which you are not sure of the definition, use this handout. If the definition is not in this handout please consult your instructor.

SECTION I. FREQUENTLY USED ABBREVIATIONS

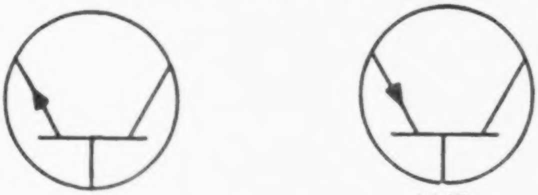
a	Amperes
A.C.	Alternating Current
A/C	Air Conditioning
ACFT	Aircraft
AN	Army-Navy (type)
ATM	Air Turbine Meter
Btu	British Thermal Unit
CB	Fire Extinguishing Agent (Bromochloromethane)
C/B	Circuit Breaker
C	Celsius (previously Centigrade)
CFM	Cubic Feet Per Minute
Cu.In.	Cubic Inches
ΔP	Delta Pressure (Differential Pressure)
D.C.	Direct Current
E	Electromotive Force (volts)
EBA	Engine Bleed Air
f	Farad
F	Fahrenheit
GPM	Gallons Per Minute
H_2O	Water
Hg	Mercury
I	Current (Intensity) (Ampere)
LPM	Liters Per Minute
Ω	Ohms
P	Power (Watts)
PPM	Pounds Per Minute
PHE	Primary Heat Exchanger
psi	Pounds Per Square Inch
psia	Pounds Per Square Inch Absolute
psid	Pounds Per Square Inch Differential
psig	Pounds Per Square Inch Gauge

Supersedes 3ABR42331-HO-101, 3AAR42371-HO-102, 7 August 1979.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

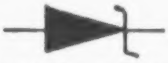
R	Resistance (Ohms)
rpm	Revolutions Per Minute
SHE	Secondary Heat Exchanger
SOV	Shutoff Valve
σ	Sigma
v	Volts
w	Watts

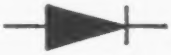
SECTION II. FREQUENTLY USED SYMBOLS

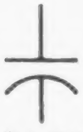
SOLID STATE

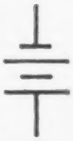

NPN PNP

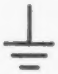
TRANSISTORS

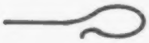

ZENER DIODE

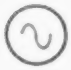

DIODE

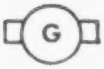

CAPACITOR


BATTERY

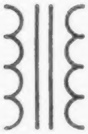

GROUND

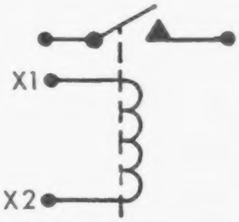

DEAD END


AC GENERATOR

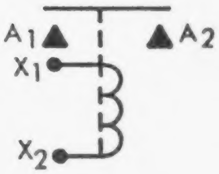


DC GENERATOR

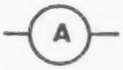

TRANSFORMER

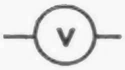


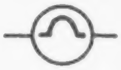
SPST RELAY
(FIXED-CORE TYPE

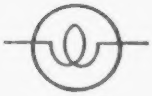


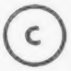
SPST RELAY
(SOLENOID-TYPE)

AMMETER 

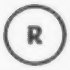
VOLTMETER 

OHMMETER 

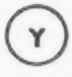

LAMP



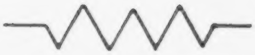
CLEAR LAMP



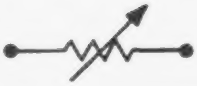
RED LAMP



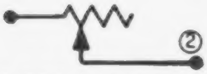
YELLOW LAMP



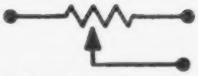
FIXED RESISTOR



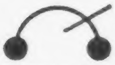
VARIABLE RESISTOR
(SENSOR)



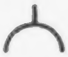
RHEOSTAT (INTERNAL)
(VARIABLE)



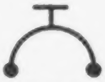
POTENTIOMETER
(VARIABLE RESISTOR)



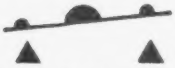
CIRCUIT BREAKER
(TOGGLE-TYPE)



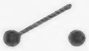
CIRCUIT BREAKER
(PUSH)



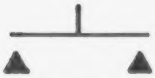
CIRCUIT BREAKER
(PUSH-PULL)



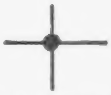
MICROSWITCH
(LIMIT SWITCH)



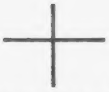
SPST SWITCH
(TOGGLE)



PUSH-BUTTON SWITCH

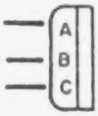


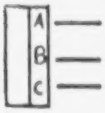
CONNECTION



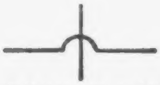
CROSSING
(NO CONNECTION)

PLUG
(3 WIRE)

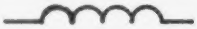




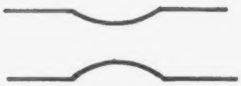
RECEPTACLE
(3 WIRE)



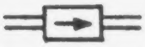
CROSSING WIRES
(NOT SPLICED)



COIL (WINDING)



VENTURI



CHECK VALVE

SECTION III. DEFINITIONS OF GENERAL TERMS

-A-

ABORT	1-Of airborne persons or aircraft; to turn back from an aerial mission before completion, especially for reasons other than enemy action. 2-To cause an air mission, sortie, or operation to fall short of success for reasons other than enemy action.
ABSOLUTE TEMPERATURE	A temperature expressed in terms of a scale beginning at absolute zero.
ABSOLUTE ZERO	Relating to a temperature scale on which the zero point corresponds to complete absence of heat. It is equal to -459.69°F and -273.16°C.
ACCELERATION	The action or process of velocity increase; the rate of velocity increase, often measured in G's.
ACCESSORY DRIVE	A special driveshaft and gears, operated off the engine, to actuate and drive accessories.
ACTUATE	To put into use; to move; to cause to operate.
AERODYNAMIC BREAKING FAN	A fan designed to create a drag on the turbine of some aircraft starters, thereby limiting the turbine speed.
AERODYNAMIC HEATING	The heating of an aircraft due to the friction of air, significant chiefly at high speeds.
AIR	The mixture of gases in the atmosphere. The element through which aircraft fly.
AIR CONDITION	The process of conditioning air. This is done by heating, cooling, cleaning the air, and controlling moisture content.
AIR FLOW	The movement of air.
AIR INLET	An entrance for air.
AIR INTAKE	A scoop, duct, or the like for taking in air; an air inlet.
AIR PRESSURE	Either the static or dynamic pressure of air or both.
AIR SCOOP	A device or part mounted on the aircraft which opens toward the front for taking in air during flight.

AIR SEAL	Any partition, gasket, or the like used to block off or stop the flow of air.
AIR START	An act or instance of starting an airplane's engine while in flight.
ALTIMETER	A flight instrument that indicates altitude above a given reference level, as above the sea or ground.
ALTITUDE	The elevation of an object above a given level, as above sea or ground. The vertical distance between any point in the atmosphere or air and a reference point on the earth's surface.
AMBIENT	Surrounding, as in ambient air, and ambient temperature.
ANEROID	A disc shaped metallic capsule from which all air has been evacuated, which expresses its sensitivity to changes in atmospheric pressure by expanding and contracting.
ANOXIA	Literally the absence of oxygen in the blood cells, or tissues, as would be the case if a person were at 50,000 feet without benefit of oxygen equipment.
ANTI (prefix)	Counter; against; opposing.
ANTI-G SUIT	A suit designed to protect a person against positive G forces over 1.75 G.
ANTI-ICER	A device designed to prevent the formation of ice.
ANTI-ICING	Of a compound, a fluid or equipment that prevents icing.
ANTI-ICE SCREEN	A wire mesh screen located in the turbine outlet of some air conditioning systems that is designed to prevent icing of the water separator.
ATMOSPHERE	The mass of air which surrounds the earth.
ATMOSPHERIC PRESSURE	The static force or pressure exerted by the atmosphere in any direction in any part of the atmosphere.
AUTOMATIC TEMPERATURE CONTROL	Designating mechanisms that work in reaction to certain conditions to automatically control the temperature of an aircraft cockpit or cabin.
AUXILIARY	Of air operated systems; that supplements or is in addition to regular air operated systems, as in rain removal systems, anti-G suit systems, canopy seal systems, and windshield defogging and anti-icing systems.

AUXILIARY POWER UNIT	A power unit that can be used in addition to, or in place of other sources of power.

B

BAILOUT	The act of leaving an aircraft by parachute during an emergency.
BAILOUT OXYGEN BOTTLE	A portable metal bottle containing oxygen to be used by a person after bailout at high altitudes. Sometimes called a "bailout oxygen cylinder."
BALL BEARING	A bearing in which the moving parts operate against freely revolving steel balls contained in a race, chiefly for the purpose of reducing friction; anyone of the balls in such a bearing.
BAROMETER	An instrument for measuring atmospheric pressure, used in such instruments as an altimeter.
BAROMETRIC PRESSURE	Atmospheric pressure as measured by a barometer.
BAROMETRIC SWITCH	A switch activated by an aneroid reacting to a atmospheric pressure.
BELLOWS	An open, flexible container operated by atmospheric pressure.
BENCH CHECK	A work shop check of the condition, completeness, or working order of a piece of equipment.
BENDS	A painful cramping in the joints caused by a rapid rise to high altitudes without the use of oxygen.
BERNOULI'S LAW	A law of physics stating that as the velocity of a fluid increases, its internal pressure decreases.
BLEED	To drain or divert all or part of the contents of an air line or chamber.
BLOWER	A device for moving large volumes of air at low pressures.
BOILING POINT	The temperature at which a liquid vaporizes upon addition of heat. The boiling point will depend upon the pressure exerted upon the surface of the liquid.
BONDING	A system of connections or contacts which insure that the metal parts of an aircraft form a continuous electrical unit thus preventing the arcing of static electricity.

BOUNDARY LAYER	A thin layer of air next to an air foil, distinguishable from the main air flow by distinctive flow characteristics of its own set up by friction.
BOUNDARY LAYER CONTROL	The design or control of airfoils and certain airfoil attachments to reduce or remove undesirable aerodynamic effects, caused by the boundary layer; the science of such design and control.
BOURDON TUBE	A metallic C-shaped or coil shaped tube open at one end to receive gas or fluid pressures, used in certain instruments as a pressure measuring device.
BREATHER TUBE	A tube providing an opening in an oil sump used to equalize the pressure in the oil sump with atmospheric pressure.
BREECH	The container on a cartridge starter where the cartridge of ammonium nitrate is placed, for igniting.
BRITISH THERMAL UNIT	A unit of heat. The heat required to raise the temperature of one pound of water one degree Fahrenheit. Also, the heat to be removed in cooling one pound of water one degree Fahrenheit.
BUCKET	One of the blades or vanes attached to a turbine wheel.
BULKHEAD	A partition or frame serving to divide, support or give shape to the fuselage of an airplane.
BURNER CAN	A combustion chamber in a jet engine or combustion heater.
BY-PASS	1-A path for current or fluid to be carried around something. 2-A route used as an alternate when some obstruction makes use of the normal route impracticable.
BYPASS, HOT GAS	A connection from the discharge side, directly to the suction side of a compressor. Sometimes used as a means of capacity control.

-C-

CABIN	An inclosed compartment in an aircraft for passengers or crew members. Also known as cockpit.
CABIN HEATER DUCT	A duct for conveying heater air to an aircraft cabin.
CABIN LEAKAGE TESTER	Used to supply air to the aircraft cabin for testing the cabin for air tightness under pressurized conditions.
CABIN PRESSURE	The air pressure in an aircraft cabin.

CAM	1. A rotating or sliding projection (as on a wheel. 2. A part mounted on a shaft and used to impart a reciprocating or alternating motion to another part by bearing against it as it rotates.
CAM FOLLOWER	A part that rides the cam.
CANOPY	Any overhanging cover as in "a canopy of an aircraft."
CANOPY SEAL	An air seal used to seal the cabin, usually inflated by air pressure.
CAPACITY (REFRIGERATION)	It is the refrigerating effect produced and generally measured in BTUs or tons per hour.
CAPILLARY TUBE	A tube having a very small internal and external diameter. They are used to connect the thermal bulb to the upper diaphragm chamber of an expansion valve and remote temperature controller.
CAPSULE	An airtight ejectable airplane cockpit or cabin.
CARTRIDGE	A solid propellant of ammonium nitrate used to turn the turbine of a cartridge-pneumatic starter.
CARTRIDGE-PNEUMATIC STARTER	Used to start aircraft engines by use of either a solid propellant cartridge or bleed air.
CASTELLATED NUT	A nut divided into slots to receive a cotter pin and thus resembling a castle.
CELSIUS	A thermometer scale (sometimes called Centigrade) in which 0 degrees represents the freezing point and 100 degrees represents the boiling point of water under standard atmospheric conditions.
CENTRIFUGAL	Moving or directed away from the center of rotation.
CHANGE OF STATE	A change in the physical characteristics of a substance such as ice becomes water or water becomes steam.
CHECK POINT	A known or designated point used as a reference in troubleshooting an electrical system. Sometimes called test point (TP).
CHECK VALVE	A valve that automatically prevents a reverse flow of a gas or fluid.
CLEAR ICE	A transparent ice deposited in layers on the airfoils of an airplane in flight. Also called glaze.
CLIMB	Of an airplace; to ascend or gain altitude especially under power.

CO_2 (CARBON DIOXIDE)	Sometimes used as a fire extinguishing agent.
COCKPIT	See Cabin
COMBUSTION	A chemical action, or burning; the burning of a fuel-air mixture.
COMBUSTION CHAMBER	A chamber or cylinder-like assembly where fuel and air are mixed, ignited, and burned.
COMPENSATOR	Any device used to offset or allow for undesirable forces or motions.
COMPONENT	A constituent part of a whole, especially one having no function apart from the whole, as the wing of an airplane.
COMPRESSOR	A machine or apparatus for compressing something; especially for compressing air.
CONDENSE	To change state from a gas to a liquid.
CONDENSER	A device for removing heat from a gas for the purpose of causing the gas to condense to a liquid.
CONDUCTION	Heat transmission by contact of two substances.
CONSTANT FLOW OXYGEN EQUIPMENT	A kind of oxygen equipment designed to supply a continuous flow of oxygen to the user. Also called continuous flow oxygen equipment.
CONTINUOUS PRESSURE BREATHING	A kind of pressure breathing in which a minimum amount of pressure variation exists inside the mask. See pressure breathing.
CONTROL AIR	Compressed air used as a controlling device.
CONTROL PANEL	A surface or panel on which switches, rheostats, and indicators are located for controlling and supervising system operation.
CONTROL SURFACE	In a broad sense, any movable airfoil used to guide or control an aircraft including the rudder, elevators, ailerons, spoiler flaps, trim tabs, and the like.
CONVECTION	The vertical movement of a limited body of air. The rising of relatively warm, light air; the downward movement of relatively cold, heavy air.
CONVERTER	As applied to an oxygen system. A double walled, vacuum insulated container that is spherical in shape and is used as a storage space for liquid oxygen.
COOLER	Heat exchanger that cools substances flowing through it.

COOLANT	Any substance used to cool.
CORROSION	To eat away gradually by chemical action. Also called rust.
COWLING	A covering of metal or other material placed over or around an aircraft component or section for directing and regulating the flow of cooling air; for streamlining and for protecting the part or section covered.
CRITICAL TEMPERATURE	Temperature of a gas above which it cannot be liquefied by pressure alone, regardless of the amount applied.
CUT-IN POINT	The temperature or pressure at which a controller will function to start the equipment controlled.
CUT OFF SPEED	The speed at which electrical power to a starter control valve is removed, thereby closing the starter control valve and stopping the rotation of a pneumatic starter.
CUT-OUT POINT	The temperature or pressure at which a controller will function to start the equipment controlled.
CYCLE	Complete course of operation of a refrigerant back to a starting point, also used in general for any repeated process of a system.

-D-

DECELERATION	The action or process of velocity decrease; the rate of velocity decrease, often measured in G's.
DECOMPRESSION	The process of decreasing the air pressure within a chamber or cabin.
DEICER	Any of several devices used especially during flight for keeping certain surfaces of an aircraft free of ice.
DEICER BOOT	A rubber strip on the leading edge of an airfoil actuated pneumatically to break the ice that has formed.
DEMAND REGULATOR	A device used in an aircraft oxygen system to supply oxygen automatically through the mask to a flyer according to the demand, the flow being controlled according to altitude.
DENSITY	The weight per unit volume of a substance.
DEPRESSURIZE	To release the pressure from a pressurized compartment of an aircraft.

DESICCANT	A chemical which absorbs moisture from the air. Used to keep the air inside packing cases or pieces of equipment dry.
DESICCATOR	A unit containing a chemical which absorbs moisture from the air.
DIAPHRAGM	A dividing partition, membrane, or capsule that expands, contracts, or vibrates, serving various purposes in certain airplane parts.
DIFFERENTIAL PRESSURE	The difference between two pressures.
DIFFERENTIAL RANGE	Applicable to aircraft pressurization; a range of altitudes where a preset differential pressure will be maintained between the inside and outside of the aircraft cabin.
DISCHARGE PRESSURE (HIGH SIDE)	Operating pressure measured at the outlet of the of the compressor.
DOUBLE HINGED SWINGING GATE DUCT SUPPORT BRACKET	A duct support bracket found in the leading edge of wing that will allow a pivot action to take place during expansion and contraction of the duct.
DRIER	A device containing a desiccant for the purpose of removing moisture from a refrigerant.
DUCT	A tube or passage for conveying air or gases to its point of use.
DUCT UNIVERSAL JOINT	A bellows type assembly placed in the duct runs to provide for absorption of movement in the ducts due to thermal stresses and structure leading.
DUMP VALVE	Applicable to aircraft pressurization; a valve used during emergencies (bailout) for rapid decompression of the pressurized areas.

-E-

ELEVATOR	A control surface, usually attached to the horizontal stabilizer, moved to make the tail of the aircraft go up and down.
ENGINE BLEED AIR	Compressed air that is bled from a jet engine or gas turbine unit.
ENGINE NACELLE	A nacelle primarily used for housing an engine and its associated parts.

EVAPORATION	The process of converting a liquid to a gas.
EVAPORATOR	Any device in which a refrigerant is evaporated for the purpose of extracting heat from the surrounding medium.
EXPANSION VALVE	A device designed to meter the flow of liquid refrigerant to an evaporator.

-F-

FAHRENHEIT	A temperature scale in which 32 degrees is the freezing point and 212 degrees represents the boiling point of water under standard atmospheric conditions.
FAN	A device for moving large volumes of air at extremely low pressures.
FEEDBACK	In electronics and electricity, feedback is the transfer of energy from the output to the input of the same electrical system.
FILTER	Any device or substance through which something is passed in order to cleanse, purify, or separate it.
FIRE EXTINGUISHER	A device used in putting out fires. May be a fixed or portable unit.
FLAMMABLE	Combustible, easily ignited.
FLAP	Any control surface such as speed brakes, dive brakes, or dive recovery brakes, that are used primarily to increase the lift or drag on an airplane.
FLASH GAS	Gas generated whenever pressure is reduced on a liquid held at a boiling temperature.
FLOODBACK	A carry-over of liquid refrigerant from the evaporator to the suction line of a refrigeration unit.
FLOWMETER	An instrument that measures and displays the rate of a large flow of a liquid or gas.
FLOWRATOR	An instrument that measures and displays the rate of a small flow of a liquid or gas.
FOLDING WING	A wing so hinged that it may be turned upward.
FORCE	Power or energy exerted against a material body in a given direction.

FRANGIBLE DISC	A device, usually made of metal, which is scored to break at the score lines when pressure is applied. Used in fire extinguisher systems.
FREEZING POINT	The temperature at which substances become stiff or immobile.
FROST	A feathery deposit of minute ice crystals or grains upon a surface or object formed directly from vapor in the air.
FUSELAGE	The main structure or central section of an airplane which houses or contains the crew, passengers, or cargo.
FUSIBLE PLUG	A safety device having an insert of a low melting point alloy. At excessive temperatures the alloy will melt and release the substance inside.
FUEL NOZZLE	Atomizes and sprays the fuel into the combustion chamber of a heater for proper burning.
FUEL PUMP	Delivers aircraft fuel under pressure to the fuel nozzles in combustion heaters and engines.

-G-

G-FORCE	The gravitational force or pull of the earth.
GAS	Any substance, like air, carbon dioxide, or chlorine that has no shape or volume independent of a container that might hold it, and tending to expand indefinitely. Distinguished from a liquid or a solid.
GAS TURBINE	A mechanical unit that spins or rotates in reaction to a flow of gas passing through or over it.
GAS TURBINE COMPRESSOR	A small gas turbine engine that is mounted on board the aircraft to provide hot, high-pressure air for ground checking of the air conditioning systems and starting aircraft engines.
GAS TURBINE UNIT	A small gas turbine engine that supplies hot, high-pressure air for aircraft use and emergency electrical and hydraulic power. This unit will be mounted on-board the aircraft. See auxiliary power unit.
GASKET	A piece or ring of rubber, metal, paper, etc., placed around a piston or joint to make it leak proof.
GAUGE	A measuring instrument. Also spelled gage.
GO-NO-GO GAUGE	A key like piece of metal used for measuring clearances between points.

GRAVITY	1-The force that makes a body, if free to move, accelerate toward the center of the earth. 2-A G-force due to acceleration and deceleration.
GROUND AIRCART	A device consisting of a small gas turbine engine used to provide hot, high-pressure air for starting the aircraft engines and ground checking the air conditioning system.
GROUND CHECK	To check or operate an aircraft on the ground before it becomes airborne.
GROUND COOLING EJECTOR	Forces engine bleed air out of a nozzle to create a low pressure area in the heat exchanger ram air exhaust, that draws cooling ram air across the heat exchanger. See jet pump.
GROUND SUPPORT EQUIPMENT	The equipment required to maintain and care for an aircraft while on the ground.
G-SUIT	A garment containing a number of bladders for covering parts of the body below the chest, designed to inflate automatically to the exact pressure to prevent or retard the pooling of blood below the heart during exposure to abnormal G forces. Also called anti-blackout suit and anti-G suit.

-H-

HEAT EXCHANGER	1-In aircraft air conditioning, a device or system whereby heat is transferred from the hot engine bleed air to the ram air, thereby cooling the engine bleed air. 2-In a more general sense, any device which transfers heat from one substance to another, such as a water radiator.
HEAT, LATENT	Heat added or removed which cannot be measured by a change in temperature but causes a change in state.
HANG FIRE	Pertaining to cartridge starters; an abnormal delay between the actuation of the ignitor and the establishment of the balanced burning pressure of the cartridge during a cartridge start.
HIGH PRESSURE OXYGEN EQUIPMENT	A kind of aircraft oxygen equipment designed to withstand a relatively high internal gas pressure.
HIT KIT SPOT WELDER	A portable welding machine that can be used to repair metal foil duct insulation.
HORIZONTAL STABILIZER	The horizontal component of an airplane's empennage extending on both sides of the fuselage.

HUMIDITY, RELATIVE	The amount of moisture in the air stated in terms of percentage of total saturation at the existing dry bulb temperature.
HYPEROXIA	Excess of oxygen in the body.
HYPERVENTILATION	Over breathing; excessive loss of carbon dioxide from the blood.
HYPOXIA	Oxygen deficiency in the blood, cells or tissues.

-I-

ICING	The act or process of atmospheric moisture freezing upon the surfaces of an aircraft; the condition in which this phenomenon takes place.
IGNITER PLUG	A spark plug used to ignite the fuel mixture in a combustion heater.
IGNITION HARNESS	A system or assembly of wires, together with any shielding or conduits inclosing them, for conducting electric current to the igniter plug of a combustion heater.
IGNITION SYSTEM	The electrical system which supplies the spark for the combustion of fuel in a combustion heater.
INDICATOR	An instrument or device.
INDICATOR, RATE OF CHANGE	Indicates the rate of pressure change in the cabin or cockpit of an aircraft.
INNER LINER	The inner shell of a combustion chamber inserted to diffuse the compressed air in the chamber and maintain an efficient flame pattern.
ISOBARIC PRESSURE	Having the same barometric pressure.
ISOBARIC RANGE	Applicable to aircraft pressurization; a range of altitudes where the atmospheric pressure in the cockpit is held at the same pressure regardless of the aircraft altitude.

-J-

JET PUMP	A device that will create a low pressure area in the ram air outlet of a heat exchanger which will draw additional ram air across the heat exchanger. See ground cooling ejector.
JET NOZZLE	A nozzle producing a jet of liquid or gas. An exhaust nozzle for the escape of gases.

-K-

KINETIC	Pertaining to or due to motion.

-L-

LABYRINTH SEAL	A carbon seal used in refrigeration packs of aircraft air conditioning systems.
LAMINATED METAL	Metal consisting of two or more metal plates bonded securely together.
LANDING FLAP	A flap used especially to slow an airplane down for landing.
LAW OF HEAT TRANSFER	Heat always travels from hot to cold.
LEAK TEST	Tests made in various manners to determine the existence and location of leaks.
LEAK TEC	A soapy solution used to determine the existence and location of leaks in an oxygen system.
LIMIT SWITCH	On valves; a switch that is actuated when the open or closed limits of a valve are reached.
LINE, DISCHARGE	Refrigerant piping or tubing between the compressor and condensor.
LINE, LIQUID	Refrigerant piping or tubing between the receiver and expansion valve.
LIQUID	A substance, like water, neither solid nor gaseous, that flows freely and conforms to the shape of a container.
LITER	A liquid measure. Approximately 34 ounces.
LOAD, HEAT	The amount of heat per unit time imposed on a refrigerant system or the required rate of heat removed.
LOW PRESSURE OXYGEN EQUIPMENT	A kind of aircraft oxygen equipment designed to function at a relatively low internal gas pressure.
LOW SIDE (SUCTION SIDE)	Part of a refrigerant system in which a refrigerant pressure corresponds to the evaporator pressure.
LUBE	Short for lubricating oil.

-M-

MANOMETER	Used to measure absolute and differential pressures.

MASTER SWITCH	The main switch that will control the starting and stopping of the entire system.
MATTER	Anything that has weight and occupies space.
MERCURY BAROMETER	A barometer using mercury as the sensitive element for measuring atmospheric pressure.
METAL FOIL INSULATION	An insulation wrapped around hot air ducts to minimize the heat loss from the ducts, prevent damage to the structure and equipment adjacent to the ducts, and prevent injury to personnel coming in contact with the ducts.
MINIMUM TEMPERATURE CONTROL SYSTEM	An aircraft temperature control system designed to prevent the temperature of the refrigerated air from getting too low.
MISFIRE	Pertaining to the cartridge starter, the failure of the cartridge of a cartridge starter to ignite.
MICRON	Measurement of size used in rating filters.
MODULATING VALVE	A valve that, as part of a cabin temperature control systems, varies its position to maintain the temperature at a constant point.
MOISTURE SEPARATOR	A device used to remove moisture from an aircraft air conditioning system.

-N-

NACELLE	A separate streamlined inclosure on an airplane for sheltering and housing something.
NEGATIVE G	A G-force exerted upon the human body acting from the foot to head.
NEGATIVE TEMPERATURE COEFFICIENT	Characteristic of a device or substance in which its resistance is indirectly proportional to change in its temperature. (If temperature increases, its resistance decreases; if temeprature decreases, its resistance increases.)
NOMENCLATURE	A set of systems of names or symbols given to items of supply and equipment, or to other variously identifiable thing as a means of classification and identification.
NOZZLE	A duct through which a liquid or gas is directed, designed to increase the velocity of the liquid or gas.
NULL	A condition existing when a minimum unbalance signal is received from a bridge circuit. The bridge circuit is at balance.

NULL INDICATOR	A center scale ammeter connected across a bridge circuit and used to indicate whether the bridge circuit is at balance.

-O-

O-RING SEAL	A synthetic rubber seal made in the shape of the letter O that is used to prevent leaks.
OIL COOLER	A kind of a radiator in the lubrication system of an aircraft for cooling the lubricating oil.
OIL DIPSTICK	A dipstick for measuring oil in tanks or similar containers.
OIL FILTER	A device used to remove foreign matter from the oil before it reaches the areas to be lubricated.
OIL LEVEL	The level in a unit or component at which oil must be carried for proper lubrication.
OIL PRESSURE FAILURE SWITCH	A device on the refrigeration system which acts to shut off a compressor when oil pressure falls below a predetermined point.
OPEN WORK ORDER	A work order or job that has not been completed.
ORIFICE	An opening; mouth or outlet of a tube, cavity vent. A calibrated circular hole used to regulate flow.
OUTSIDE AIR TEMPERATURE	The temperature directly outside the aircraft (ambient).
OVERRUNNING SPRAG CLUTCH	Part of an aircraft starter that transmits the torque of the turbine only in one direction, thereby preventing the aircraft engine from driving the starter after the engine starts.
OXYGEN	A chemical element, occurring free in the atmosphere as an odorless, colorless, tasteless gas and also in combination in other substances. It can be compressed to a liquid state.
OXYGEN BOTTLE	A metal bottle designed to hold oxygen for breathing at high altitudes.
OXYGEN LACK	A condition of scarcity or absence of oxygen in the atmosphere, as at high altitudes, or in a confined space unsupplied by oxygen.
OXYGEN MASK	A mask that covers the mouth, nose, and lower face, used in inhaling oxygen from a tank or bottle.
OXYGEN STATION	A place or point in an aircraft where an oxygen mask can be attached to the oxygen supply system.

OXYGEN TENSION	The faculty of oxygen at a given pressure and a given amount to extend itself into the cells of lungs or into the blood or tissues of the body.

-P-

PACK PRESSURE LIMITER	A pneumatically actuated type unit designed to regulate the airflow going to the air conditioning system.
PERIODIC DOCK	A dock for the periodic inspection or overhaul of an aircraft or engine.
PERIODIC INSPECTION	An inspection repeated either at regular intervals of calendar time or in reference to certain equipment after it has been used for a given number of times.
PHILLIPS SCREW	A holding screw having a special head with two slots which cross one another and are deeper at the center than at the ends.
PHILLIPS SCREWDRIVER	A cross tipped screwdriver; to be used with a Phillips head screw.
PISTON ENGINE	A reciprocating engine, especially an internal-combustion reciprocating engine.
PLENUM CHAMBER	An air chamber opening into the compressor chamber on certain turbojet or turboprop engines where air is collected for the compressor.
PNEUDRAULIC	Of or pertaining to mechanisms or devices that work by both pneumatic and hydraulic action.
PNEUMATIC	1-Mechanisms, devices, or tools worked by compressed air or other gases. 2-Also used to designate associated devices as in pneumatic compressor.
POSITIVE G	A G-force exerted upon the human body acting from the head to the feet.
PRECOOLER	A device used to initially cool the engine bleed air.
PREFLIGHT INSPECTION	1-A regular procedure followed by a ground crew each time or each day before a particular aircraft is flown. 2-A regular part of the periodic inspection made before the aircraft is given a flight test.
PREHEATER	A device for warming up something before use.
PRESSURE	Amount of force distributed over each unit of area. Expressed in pounds per square inch (psi).
PRESSURE, ABSOLUTE	Pressure measured in reference to zero pressure.

PRESSURE, ATMOSPHERIC	The pressure exerted by the earth's atmosphere. Under standard conditions, at sea level, atmospheric pressure is 14.7 psia or 0 psig.
PRESSURE ALTIMETER	An altimeter that measures and indicates altitude by means of differences in atmospheric pressure.
PRESSURE ALTITUDE	1-A simulated pressure altitude in a low pressure chamber. 2-either indicated pressure altitude or calibrated pressure altitude.
PRESSURE BREATHING	The breathing of oxygen or other suitable gases through a special system or apparatus at a pressure in excess of the ambient pressure.
PRESSURE CABIN	A pressurized cabin.
PRESSURE DEMAND OXYGEN EQUIPMENT	A kind of low pressure oxygen equipment that functions either as demand oxygen equipment or as continuous pressure breathing.
PRESSURE GAUGE	A gauge or instrument that measures pressure, or is actuated by pressure.
PRESSURE DROP	The loss of pressure due to friction.
PRESSURE RATIO	A ratio between two pressures as the ratio between the inlet and outlet pressures of a compressor.
PRESSURE REGULATORS	Devices which establish the working pressures in a system and maintains them at that point.
PRESSURE SUIT	A garment designed to provide pressure upon the body so that the respiratory and circulatory functions may continue normally.
PRESSURE SWITCH	1-Composed of a sealed case with an air inlet connection, diaphragm assembly, and double set of electrical contacts. Air pressure against the diaphragm operates the electrical contacts. 2-A switch activated by a given ambient pressure.
PRESSURE, TEMPERATURE, & VOLUME RELATIONSHIP	As pressure increases, temperature increases and volume decreases.
PRESSURIZATION	The term used to designate the pressurizing of aircraft cabins to a lower altitude.
PRESSURIZE	To produce and maintain in a cockpit, cabin or compartment of an aircraft an air pressure higher than the ambient atmospheric pressure, in order to compensate for the lowered pressures at high altitudes.

PUMPDOWN	The reduction of pressure within a system.
PUMP, OIL	Supplies pressurized oil for lubrication purposes.
PURGE	1. The discharge of impurities, noncondensibles or gases. 2. To clean.
PYROMETER	Precision measuring instrument for temperature indications.

-Q-

QUADRICYCLE LANDING GEAR	A landing gear consisting of four separate wheel units.
QUICK DISCONNECT FITTING	A pipe or electrical fitting in an aircraft designed for ready disconnection and connection.

-R-

RADIAL FLOW COMPRESSOR	A centrifugal compressor in which air is drawn into a rotating impeller axially, being discharged radially at the circumference of the impeller at high velocity into a diffuser, where velocity is reduced resulting in conversion of kinetic energy into pressure energy.
RADIATION	1-The act or process of radiating or the state of being radiated; also, that which is radiated. 2-The combined process of emission, transmission, and absorption of radiant energy.
RAM	The forward motion of an air scoop or air inlet through the air.
RAM AIR SCOOP	A scoop extended into the air stream to provide an emergency source of ram air for ventilation of the crew compartment of the airplane.
RANKINE SCALE	A temperature scale that uses Fahrenheit degrees, but makes the 0 degree signify absolute zero (degrees R). The freezing point of water on the Rankine Scale is 491.69°.
RECEIVER	A device for storing liquid refrigerant.
REDUCTION GEAR	A gear assembly between a powered shaft and another shaft, by which the latter shaft is driven at a lower rpm than the powered shaft.
REED AND PRINCE SCREWDRIVER	A trade name for a kind of screwdriver having a blunt tip and a cross shaped cross section at the top.
REFRIGERATION SYSTEM	A system in which a refrigerant is circulated for the purpose of extracting heat.

REGULATION	The act of governing, controlling, or directing; or the state of being controlled or directed.
REGULATOR	A device that regulates the flow or pressure of a liquid gas.
REGULATOR, AIR PRESSURE	A device that establishes the working pressure of an air operated system and holds it at that point.
REGULATOR, CABIN PRESSURE	A device that controls cabin pressure by controlling the amount of pressurized air leaving the cabin.
REGULATOR, CABIN TEMPERATURE	A device operated either electrically, electronically, or pneumatically provided to maintain cabin temperature at a predetermined setting.
REGULATOR, CANOPY SEAL	A device that regulates air pressure for pressurizing the canopy seal.
RELIEF VALVE	A safety valve used to relieve excessive pressure.
RUPTURE DISC	A metal disc installed in an air conditioning, fire extinguishing, or oxygen system that will burst when pressure becomes too high.

-S-

SEAL	A device to prevent leakage of liquid, gas, or air.
SEALANT	A sealing compound.
SEAT, VALVE	That part of a component which forms the seal between the housing and the valve when the valve is in the closed position.
SENSIBLE HEAT	Heat added or removed which can be measured by a change in temperature.
SIGHT GAUGE	Used to observe the condition of a fluid in a system or component.
SOLENOID	A coil of insulated wire wound in the form of a spring or on a spool. A solenoid uses DC or AC for its operation.
SOLENOID VALVE	A valve actuated by a solenoid.
SPRING LOADED	Held or driven under spring pressure.
SQUIB	1-Any of various small size explosive devices. 2-Specifically an electrically detonated explosive charge in a thin walled metal container.
STATIC AIR PRESSURE	Static pressure exerted by air upon an object especially by the air of the atmosphere as in a pitot-static tube.

STATOR	In machinery, a part that remains fixed in relation to a rotating part.
STATOR BLADE	A blade or vane that remains fixed with respect to a rotating blade.
STRUT, ENGINE	Any rigid structure that protrudes from a wing, fuselage, or other surface of an aircraft to support an engine.
SUBASSEMBLY	A unit or element of a major assembly, consisting of two or more separate parts assembled together.
SUBCOOLING	The cooling of a liquid below its condensing temperature.
SUCTION LINE REFRIGERANT	Tubing or piping which connects the evaporator to the compressor.
SUMP	A reservoir at a low point in a fuel or lubrication system where the liquid is collected and stored.
SUPER HEAT	Temperature added to a substance above its boiling point.
SWINGING GATE DUCT SUPPORT BRACKETS	Brackets mounted in the leading edge of the wings to allow a pivot action to take place during expansion and contraction of the ducts.
SWITCH, DIFFERENTIAL PRESSURE	An electrical switch actuated by differential pressure.
SWITCH, PRESSURE	An electrical switch that is opened or closed when a specified pressure is applied to it.
SWITCH, THERMAL	An electrical switch made of bimetallic contacts that will open or close in response to the temperature it senses.

-T-

TACHOMETER	An instrument that indicates in revolutions per minute the rotational speed of a unit.
TECHNICAL ORDER	An AF publication that gives specific technical directions and information with respect to inspection, storage, operation, modification, and maintenance of given AF equipment.
TECHNICAL ORDER KIT	A kit consisting of the tools or parts necessary to use or maintain a piece of equipment as prescribed in an AF TO.
TEMPERATURE	Degree of hotness or coldness measured on a definite scale.

TEMPERATURE, AMBIENT	The temperature of the air surrounding the object under consideration.
TEMPERATURE SELECTOR	A device used by the crew members to select the temperature to be maintained in the cockpit or cabin.
TEMPERATURE SENSING ELEMENT	A temperature sensitive resistance that is part of the balance bridge circuit and senses the temperature changes that take place in the cabin or the duct.
TEST SET	A set of equipment used to test system operation and locate faults and troubles in the systems maintained by this career field.
TEST STAND	A strong stationary stand on which the component part of the systems found in this career field are tested for operation.
THERMAL COMPENSATOR	A device installed in the ducts of the bleed air system to allow for linear growth of the duct caused by thermal expansion of the duct.
THERMISTOR	A small resistor in which the resistance varies over a wide range with temperature.
THERMOCOUPLE	A connection or junction of two pieces of dissimilar metals which produces a current when heated.
THERMOSTAT, MERCURY	An apparatus consisting of a glass tube and metal contacts in which mercury rises and falls as it expands or contracts from changes in temperature. This unit is used to regulate temperature in an aircraft cabin.
TOLERANCE COMPENSATOR	A device installed in ducts in the bleed air system to improve the necessary adjustments in duct lengths due to duct and aircraft tolerances.
TON OF REFRIGERATION	A unit of refrigeration capacity. Equal to 12,000 BTUs per hour or 288,000 BTUs per 24 hours.
TORQUE	A movement that produces or tends to produce rotation, twisting, or torsion.
TORQUE WRENCH	A wrench designed to disengage when the torque required to turn a bolt or nut increase beyond a certain point.
TRANSDUCER	Any device that changes one type of signal to another.
TRICYCLE LANDING GEAR	A three wheel landing gear in which no tail wheel or tail skid is used, normally consisting of two main wheels with an auxiliary wheel forward.
TURBINE	A mechanical device that spins in reaction to an airflow passing over or across the vanes.

TURBINE COMPRESSOR	A combination of a turbine wheel and a compressor wheel mounted on the same shaft. The compressor is used to raise the temperature and pressure of the air passing through it and put a load on the turbine to keep it from overspeeding. The turbine cools the air applied to it by rapid expansion and by converting heat energy to mechanical energy. This unit is the cooling unit found in some aircraft air conditioning systems.
TURBINE AND FAN ASSEMBLY	An expansion type cooling unit used in some aircraft air conditioning systems. The fan is used to put a load on the turbine and draw ram air across a heat exchanger. The turbine cools the air applied to it by rapid expansion and by converting heat energy to mechanical energy.
TURBINE WHEEL	A wheel or disc equipped with blades or vanes designed to spin in reaction to an air flow passing over or across the vanes.
TURBOJET ENGINE	A type of jet engine that uses a gas turbine to drive an air compressor and engine accessories.
TURBOPROP ENGINE	A turbojet engine designed to drive a propeller by transmitting power through a shaft.

-U-

UNPRESSURIZED RANGE	Applicable to aircraft pressurization, the range of altitudes where both the aircraft altitude and cabin altitude are equal.
USEFUL OIL PRESSURE	The difference in pressure between suction pressure and compressor oil pressure.

-V-

VACUUM	A reduction of pressure below atmospheric pressure; usually stated in inches of mercury.
VACUUM PUMP	A pump for exhausting a system. A pump designed to produce a vacuum in a closed system or vessel.
VALVE	Any device such as a swirling plate, hinged lid, plug, or ball through which the flow of gas or liquid may be checked, stopped, started, or regulated.
VALVE, AIR CONDITION SYSTEM SHUT OFF	A device used to stop and start the flow of engine bleed air to the air conditioning system.
VALVE, ANTI-G SUIT	A device that regulates the pressure going to the anti-G suit and stops and starts the air flow going to the suit.

VALVE, BLEED AIR PRESS. REGULATOR & SHUT OFF	A device that starts and stops the flow of engine bleed air going to the air conditioning system and regulates the pressure.
VALVE, BUTTERFLY	Usually a round type valve with an upper and lower bearing.
VALVE, BYPASS	A passage for air to go around a unit.
VALVE, CO_2 DIRECTIONAL	Used on aircraft fire extinguisher installations to direct the CO_2 to the desired engine.
VALVE, CO_2 TRIGGER RELEASE	Used on portable CO_2 fire extinguishers to start and stop flow of CO_2 at will.
VALVE, CO_2 QUICK RELEASE DISCHARGE	Used on CO_2 fire extinguishers to release the CO_2; this valve, once opened, will be held open constantly and cannot be shut off.
VALVE, FLOW CONTROL & SHUTOFF	A device used on some aircraft air conditioning systems that operates as both a shut off valve and an air flow control valve.
VALVE, RAM AIR	Allows air to enter the cabin directly from the outside.
VALVE, SAFETY RELIEF	A valve designed to relieve the pressure from a vessel or system whenever the pressure exceeds the setting of the valve.
VALVE, SLIDING GATE	Used in low pressure systems; consists of a piece of metal that slides to open or close the opening in the duct or valve.
VALVE, SPOON	Usually a round valve with 2 upper bearings and no lower bearing.
VALVE, WATER SEPARATOR BYPASS	A pneumatically operated valve that opens when the water separator becomes plugged or frozen to allow conditioned air to bypass the separator and enter the cockpit area.
VALVE, VACUUM RELIEF	Applicable to aircraft pressurization; a valve that prevents outside atmospheric pressure from exceeding inside the cabin pressure. Valve will open to allow high outside pressure to equalize the pressure inside.
VAPOR	Any substance in its gaseous state.
VAPORIZE	1-To convert something into a gaseous state, as through spraying or heating a liquid. 2-Of a liquid to go into a gaseous state.
VARIABLE AREA NOZZLE	A nozzle the opening of which is a variable size.

VELOCITY	1-Speed. 2-Speed or rate of motion in a given direction and in a given frame of reference.
VENTILATION	The process of moving air through the cabin area.
VENTURI	1-A venturi tube. 2-A device used to control the flow of air in an air conditioning system.
VENTURI TUBE	A short tube with a constricted throat which, when placed in a fluid flow parallel to the flow, brings about an increase in flow velocity at the throat with a consequent reduced pressure within the fluid at the throat.
VOLATILE	Easily passing away by evaporation.
VOLATILITY	The quality or property of a liquid for evaporating.
VOLUME	Amount of space included by the bounding surface of an object.

-W-

WALK AROUND OXYGEN BOTTLE	A carry around oxygen bottle.
WARNING LIGHTS	A system of lights that illuminate to give the pilot warning of a malfunctioning system.
WATER BOILER	A type of heat exchanger that uses water as the cooling agent; heat energy is transferred from the engine bleed air to the water causing the water to boil and evaporate.
WATER SEPARATOR	A device in an aircraft air conditioning system designed to remove the water condensed in the air as a result of refrigeration.
WICK	Pertaining to a turbine used for cooling; allows oil to flow to the blanket by absorption.
WING ROOT	The very base of an airplanes wing, where it joins and is faired into the fuselage.

SECTION IV. ELECTRICAL TERMS DEFINITIONS

-A-

A-C Generator	Rotating electrical machine, generally known as an alternator that converts mechanical power into alternating current.
Adjustable Resistor	Resistor whose resistance can be changed mechanically.
Air Gap	The space between any two iron or steel elements in a magnetic circuit.
Alnico	An alloy of iron with aluminum, nickel and cobalt having magnetic properties such that it can be used to produce an extremely strong magnet with relatively small mass.
Alternating Current (AC)	Current periodically changing direction and constantly changing amplitude.
Alternation	A term used to signify that part of the change in an alternating current during which it rises from zero to maximum and back to zero again. Half of one complete cycle.
Alternator	An alternating current generator.
Alternator. Three-Phase	Produces 3 voltages 120° apart.
Ammeter	An instrument for measuring current, with a scale graduated to read directly in amperes.
Ampere (Amp)	A practical unit of current. The amount of current flowing through one ohm resistance at the pressure of one volt.
Ampere-Hour (AH)	A current of one ampere flowing for one hour. Term used in rating storage batteries.
Ampere-Hour Capacity	The amount of current a battery can provide for one hour. Theoretically, a battery rated at 100 ampere-hours will furnish 100 amperes for 1 hour, or 50 amperes for 2 hours, or 5 amperes for 20 hours.
Ampere-Turn	The magnetizing force produced by one ampere of current flowing through one turn of a coil in an electromagnet.
Amplification	A process whereby a small fluctuating signal voltage or current is stepped up to a value many times greater than its original strength.

Amplifier	A device used to increase the signal voltage, current or power. It may contain several stages in order to obtain a desired gain.
Amplitude	The maximum value of the displacement from the zero position.
Anode	A positive electrode, such as the plate of the vacuum tube or capacitor.
Armature	As applied to: Motors or DC Generators - It refers to the movable or rotating part, consisting essentially of coils of wire around an iron core. Alternators - The circuit which contains the conductors that have the EMF induced in them and that are in series with the load. Relays - The moving portion of a relay device.
Arc	A discharge of electricity through a gas.
Armature Core	Assembly of laminations forming the magnetic circuit of the armature.
Armature Reaction	Reaction between the magnetic flux of the armature and that of the main magnetic field.
Atom	One of the minute particles of which the universe is composed; a natural group of electrons, protons and neutrons.
Attraction	The force that tends to make two objects approach each other. Attraction exists between two unlike magnetic poles and between two unlike static charges.
Automatic Circuit Breaker	Device that automatically opens a circuit, usually through thermal means, when the current exceeds a safe value.
Autotransformer	A transformer having one continuous winding. A part of this winding is used for both the primary and secondary coil.

-B-

Back Electromotive Force	The counter EMF of any system is the effective EMF within the system which opposes the passage of current in a specified direction.
Ballast Resistance	A steadying resistance used to limit variations of current in a circuit.

Barrier Layer	Surface of contact between a metal and semiconductor. It acts as a rectifier of alternating currents.
Battery	A device for converting chemical energy into electrical energy.
Bias	A fixed voltage, usually negative, applied to the grid of a vacuum tube so that it operates along a certain portion of its characteristic curve.
Bimetallic	Always made up of two unlike metals.
Bleeder	A resistance connected in parallel with a power-supply output to protect equipment from excessive voltages if the load is removed or reduced; to improve the voltage regulation and to drain the charge remaining in the filter capacitors when the unit is turned off.
B-power Supply	Power source which supplies positive voltage for other electrical devices.
Bonding	Connecting the metal parts of the aircraft with flexible conductors, so that all parts will have the same voltage or potential.
Breakdown Voltage	1. Voltage at which an insulator or dielectric ruptures. 2. Of a semiconductor diode, the voltage measured at a specified current in the breakdown region.
Bridge Circuit	A network in which the output indicating device or the load is bridged across intermediate points of the two parallel elements across which the input voltage is applied.
Bridge Rectifier	Full-wave rectifier with four elements connected in a bridge so that direct voltage is obtained from one pair of opposite junctions when alternating voltage is applied to the other pair.
Brush	A metal or carbon block used to make contact with a rotating or other moving part in an electrical circuit.
Bus Bar	Heavy metal bars used to carry current. The wires of several circuits may be connected to one or more terminals which appear on the bar.

-C-

Calibration	Process of comparing an instrument or device with a standard to determine its accuracy or to devise a corrected scale.

Capacitance (C)	That property of a system of conductors and dielectrics which permit the storage of electrical energy in an electrostatic field between the conductors; unit of measurement is the Farad.
Capacitive Reactance (X_c)	The opposition which a condenser offers to AC or pulsating DC. It is expressed in ohms.
Capacitor	A system consisting of two conductors of considerable surface separated by a comparatively thin dielectric, thus possessing an appreciable capacitance. An electrical device or unit designed especially to have the quality of capacitance (condenser).
Capacity	See capacitance.
Cathode (K)	Negative, or the electron emitting electrode of a vacuum tube.
Cell	A single unit capable of serving as a DC voltage source equal to 1.5 volts; also a single rectifier unit. Dry Cell - Composed of an outer shell of zinc, an electrolyte of paste and a carbon rod in the center. Primary Cell - Commonly called "dry cell," a battery that cannot be recharged due to a nonreversible chemical reaction that takes place between the plates and the electrolyte when the cell is in use. Secondary Cell - A battery cell that can be recharged by reversing the current flow through the battery. Wet Cell - A case containing lead coated plates and a liquid electrolyte.
Characteristic	A distinguishing trait, quality or property.
Charge	The act of supplying electrical energy to a metal object, a condenser or a storage battery. When an object has more electrons than normal, it has a negative charge. When it has less electrons than normal the object has a positive charge.
Charged Bodies	Bodies with an excess or deficiency of electrons.
Choke Coil	A coil used to impede the flow of pulsating current or alternating current by means of its self-inductance.
Circuit	A closed path usually including a source of voltage.
Circuit Breaker	An automatic switch which opens a circuit under abnormal conditions such as an overload. It also may be "tripped" or opened by hand.

Circuit Diagram	Schematic drawing of the electrical connections of a device.
Coil	A number of turns of wire wound on an iron core or a number of turns of wire wound on a form of insulating material.
Coil, Toroidal	A coil wound in the shape of a doughnut.
Cold Cathode	A type of cathode which does not require heat to emit electrons.
Collector	In a transistor, an electrode through which a primary flow of carriers leaves the interelectrode region.
Collector Junction	In a transistor, a junction normally biased in the high resistance direction, through which the current can be controlled by the introduction of minority carriers.
Collector Rings	"Sliprings" - a contact ring for making connection through brushes between a winding on a rotating part of a machine or apparatus and an external circuit.
Commutation	The process of converting alternating current which flows in the armature of a DC generator to DC.
Commutator	A drum built up of insulated segments connected to the armature winding of a generator or motor to or from which current is taken by the brushes.
Component	A functional part of a subsystem or electrical circuit which is essential to the operational completeness of the subsystem of circuit.
Condenser	See capacitor.
Conductance (G)	The ease with which a conductor passes current. The reciprocal of resistance. Expressed in ohms.
Conductor	Any material which possesses an appreciable proportion of free electrons and therefore permits a current to pass.
Contact	Part of an equipment designed to touch a similar part to permit current to flow, or designed to break this union to cause current to cease.
Contactor	A device for repeatedly establishing and interrupting an electric circuit.
Continuity	The property of having a complete or continuous electrical path.

Control Grid (G)	The electrode of a vacuum tube, other than a diode, upon which the signal voltage is impressed in order to control the plate current.
Control Panel	A panel, open or closed, where switches, rheostats, meters, etc., are installed for controlling and protecting electrical machinery.
Copper-oxide Rectifier	A metallic rectifier made of alternate layers of one or more discs of copper on copper-oxide.
Core	Magnetic material placed within a coil to increase the magnetic intensity of the magnetic field. Magnetic material inside a relay or inductor coil winding.
Coulomb (Q)	A quantity of electricity; the number of electrons passing a point, in a given conductor when one ampere flows for one second.
Counter Electromotive Force	A voltage (CEMF) induced in a coil or conductor of opposite direction to the applied voltage.
Current (I)	Movement of electrons as measured in amperes.
Current Limiter	An electrical device used to limit the current flow in a circuit.
Cycle (∼ or c)	One complete set of recurring events which takes place periodically.

-D-

D-C Generator	(See Direct Current Generator).
D-C Resistance	Opposition to the flow of direct current offered by a circuit or body.
Deenergize	To stop the flow of current in a circuit, or remove the voltage in a circuit, as by opening a switch.
Delta	Method of connecting the stator windings in a 3 Ø motor or generator.
Density	Concentration of anything; quantity per unit volume.
Depletion Layer	In a semiconductor, a region in which the mobile carrier charge density is insufficient to neutralize the net fixed charge density of donors and acceptors.
Dielectric	A nonconducting material.

Dielectric Constant	A numeral which describes the effectiveness of a dielectric. It compares the capacity of a condenser using dielectric with that of an otherwise identical condenser using air as a dielectric. Air has a dielectric constant of one.
Diode Tube	A two-element tube having cathode and plate. Used mostly as a rectifier. A diode allows electrons to pass in only one direction, from cathode to plate.
Direct Current (DC)	Current which is constant in direction.
	Pulsating DC - Current which varies or fluctuates in value, but flows in only one direction.
Direct Current Generator	Rotating electrical machine which converts mechanical power into D-C power.
Discharge	1. Release of stored up energy. 2. In a storage battery, the conversion of the chemical energy of the battery into electrical energy.
Dropping Resistor	Resistor used to decrease a given voltage to a lower value.

-E-

Effective Current	That value of alternating current which will cause the same effect as a given value of direct current. It is equal to .707 times maximum or peak value.
Effective Value (RMS)	The value of AC which has the same effect as the corresponding value of DC. For a sine curve the effective value is .707 times the maximum value.
Effective Voltage	That value of alternating voltage which will cause the same effect as a given value of DC voltage. It is equal to .707 times maximum or peak value.
Electrical Charge	The quantity of electricity on (or in) a body is the excess of one kind of electricity over the other kind. A plus sign (+) indicates that the positive is in excess, a negative sign (-) indicates that the negative is in excess.
Electrical Degrees	A measurement of time in an electrical cycle. One degree = 1/360 of a cycle. At 60-cycle frequency, 1 degree = 1/21, 600th of a second. The actual length of time represented by the amount of electricity produced and shown in electrical degrees with respect to mechanical degrees and time.
Electricity	A form of energy due to the separation and independent movement of certain parts of atoms called electrons.

Electrode	A solid conductor by which a current passes to or from a liquid or gas to another solid conductor of different material.
Electrolyte	The liquid or chemical paste which is used between the plates in a battery or dry cell.
Electrolytic Capacitor	Capacitor which is comprised of two plates separated by an electrolyte. Under the action of the applied DC voltage, a film of hydrogen gas is formed on one plate, and it is this film which is the electrolyte. This type of construction makes it possible to concentrate large values of capacitance in relatively small space.
Electromagnet	A magnet produced by the flow of an electric current through an associated coil.
Electromagnetic Field	Field of influence which an electric current produces around the conductor through which it flows. Magnetic field resulting from the flow of electricity.
Electromagnetic Induction	Production of a voltage in a coil due to a change in the number of magnetic lines of force passing through the coil.
Electromotive Force (emf)	That force which tends to cause an electric current or electron flow by producing a difference of potential.
Electron	The elementary charge of negative electricity.
Electron Drift	Actual movement of electrons in a definite direction through a conductor during current flow, as contrasted from transfer of energy from one electron to another by collision.
Electron Emission	The liberation of electrons. As from the cathode of a vacuum tube.
Electron Theory	The theory which explains all electrical phenomena by the independent movement of electrons.
Electrostatic	Pertaining to electricity at rest, such as charges on an object.
Electrostatic Charge	Electric charge stored on a capacitor or on an insulated body.
Electrostatic Field	Field of force between two electrically charged bodies.

Element	1. Substance, in chemistry, that cannot be divided into simpler substances by any means ordinarily available. 2. Of a semiconductor device, any integral part of the semiconductor device that contributes to its operation.
Emitter	In a transistor, a region from which charge carriers that are minority carriers in the base are injected into the base.
Emitter Junction	In a transistor, a junction normally biased in the low-resistance direction to inject minority carriers into the base.
Energy	The capacity for performing work. Energy of motion is kinetic energy. Energy of a stationery or static form is called potential energy. Energy cannot be created or destroyed but may change its form.
Energize	Supply power necessary to provide normal and effective operation.
Excess Electron	An electron introduced into a semiconductor by a donor impurity and available to promote conduction. An excess electron is not required to complete the bond structure of the semiconductor.
Exciter	A direct current generator supplying current for excitation of one or more other machines.
External Resistance	Resistance that is connected externally between the terminals of a battery or other power source.

-F-

Farad (f)	The unit of electrostatic capacity. A condenser possessing the capacity of one farad will allow one coulomb of electrons to flow upon its plates when the potential of one volt is applied for one second.
Field (Electric or Magnetic)	A term used to indicate a region where magnetic or electrostatic forces are exerted.
Field Coil	A suitable insulated winding to be mounted on a field pole to magnetize it.
Field, Differential	Field which has the series and shunt coils connected to oppose each other.
Field Distortion	Undesired shift in the fields between the N and S pole due to CEMF in the armature windings.
Field of Force	Term used to describe to total force exerted by an action-at-a-distance phenomenon such as gravity upon matter, electric charges acting upon electric charges, magnetic forces acting upon other magnetics or magnetic materials.

Field Pole	Magnetic material on which field coils may be mounted.
Field Windings	The coil of an electromagnet used to supply the magnetic field in motors and generators.
Filament	The wire through which current is sent in a vacuum tube or a light bulb to utilize the heat given off due to the current flow.
Filter	Any system of inductance, capacitance and resistance which is used to smooth the pulsations of DC from a rectifier or commutator.
Fixed Bias or Grid Bias	A bias voltage of constant value, such as one obtained from a battery, or other DC power supply.
Fixed Capacitor	Capacitor having definite capacitance value that cannot be adjusted.
Fixed Resistor	Resistor having a definite resistance that cannot be adjusted.
Flow	Passage of electrons (a current) through a conductor or through space between electrodes.
Fluorescence	Light given off as a result of electron bombardment.
Flux (Φ)	A general term used to designate collectively all the electric or magnetic lines of force in a region.
Flux Density	The number of lines of force per unit area.
Force (F)	That which tends to change the state of rest or motion of matter.
Forward Current	Current which flows upon application of a forward voltage.
Forward Direction	In a semiconductor diode, the direction of lower resistance to the flow of steady direct current.
Free Electrons	Electrons which are not bound to a particular atom, and are free to move under the influence of an electric field.
Frequency (f)	The number of complete cycles which an alternating EMF or current executes in one second. Generally, the number of recurring events in a given period of time.
Frequency Meter	A meter used to indicate the number of cycles per second of an alternating current.
Full-Wave Rectifier	Rectifier arranged so that current is allowed to pass in the same direction to the load circuit during each half cycle of the alternating current supply.

Fuse	A wire strip or bar of metal designed to melt or to interrupt the circuit when a predetermined current is exceeded.

-G-

Gain	Ratio of output to input voltage, current, or power, usually expressed in decibels.
Galvanometer	A D'Arsonval-type meter used for measuring or indicating extremely small electric currents. Its scale usually indicates relative deflection, and the actual current, voltage or charge value must be calculated.
Generator	A machine for the conversion of mechanical energy into electrical energy.
Graph	Pictorial presentation of the relation between two or more variable quantities, such as between an applied voltage and the current it produces in a circuit.
Grid	A tube element in the form of a metallic mesh or screen through which electrons pass under control of a potential applied to the grid.
Ground	A connection, intentional or accidental, between an electrical circuit and the earth, some conducting body, or chassis serving in place of the earth.
Ground Potential	Zero potential with respect to ground or earth.
Grounded	Connected to earth or to some conducting body which serves as earth.

-H-

Half-Wave Rectifier	A nonlinear device used to rectify alternating current into direct current. Only one-half of the input cycle is rectified, the output being a pulsating direct current.
Heat Sink	A device for the absorption or transfer of heat away from a critical part or parts.
Heater (H)	An electric heating element for supplying heat to an indirectly heated cathode.
Henry (h)	The unit of inductance. A circuit has an inductance of one henry when the current, changing at the rate of one ampere per second, induces one volt CEMF.
Hertz (Hz)	A unit of frequency equal to one cycle per second.

Hole	A mobile vacancy in the electronic valence structure of a semiconductor which acts as a positive charge with a positive mass.
Hole Current	The current in a semiconductor associated with apparent positive charges designated as holes.
Horizontal	Perpendicular to the direction of gravity. In the direction of, or parallel to, the horizon. On a level.
Horsepower (hp)	A unit of electrical power equivalent to the amount of power in a mechanical horsepower. Electrically, one horsepower equals 746 watts.
Horseshoe Magnet	Permanent magnet or electromagnet bent in the shape of a horseshoe or having a U shape so as to bring the pole together.
Hot	Connected, alive, energized; pertains to terminal or any ungrounded conductor. Not grounded.
Hydrometer	An instrument used to determine the specific gravity of the liquid of a storage battery; hence, the state of charge of the batte

-I-

Impedance (Z)	The total opposition, measured in ohms, offered to passage of alternating current by the resultant of resistance and capacitive and inductive reactance.
Impurity	An atom in a crystal which is foreign to the crystal. An imperfection that is chemically foreign to the perfect crystal.
Impurity, Acceptor	In semiconductors, an impurity which may induce holes.
Impurity, Donor	In semiconductors, an impurity which may induce electronic conduction.
Induced	Produced as a result of exposure to the influence or variation of an electric or magnetic field.
Induced Current	Current due to an induced voltage.
Induced Electromotive Force	The electromotive force induced into a conductor due to the relative motion between the conductor and the magnetic field.
Inductance (L)	The physical property of a circuit which tends to oppose a change in current flow.

Induction	Magnetic Induction - When a material is placed in a magnetic field it has magnetism induced into it. Self-Induction - The production of a counter-electromotive force in a conductor when its own magnetic field collapses or expands with a change in current in the conductor. Mutual Induction - (Transformer Action) - As current is varied in a conductor, a second conductor parallel to the first will have an EMF induced into it. Note: The more nearly parallel, the greater the EMF induced. If the conductors are at right angles no voltage will be induced. Electromagnetic Induction - (Generator Action) - When a conductor and a magnetic field have relative motion, a voltage is induced into the conductor. A voltage is induced if either the conductor or the field is moved. The conductor must be moved other than parallel to the lines of force.
Induction Motor	AC motor-rotation achieved by reaction of main magnetic field and the magnetic field of the induced current in the rotor.
Inductive Circuit	Circuit containing a greater amount of inductive reactance than capacitive reactance.
Inductive Reactance (X_L)	The opposition to the flow of alternating or pulsating current caused by the inductance of a conductor. X_L is measured in ohms.
Inductor	A coil. A wire lying in an armature slot and forming part of a coil. That part of a wire which moves in a magnetic field and in which an electric current or pressure is induced. The careless practice of using the word conductor for inductor should be avoided.
In Phase	Describing a condition in which two or more fluctuating components such as an AC voltage and current attain maximum values simultaneously in the same direction.
Input	1. Current, voltage, power, or driving force applied to a circuit or device. 2. Terminals or other places where current, voltage, or power, or driving force can be applied to a circuit or device.
Input Transformer	Transformer used to transfer energy from a voltage source to the input of a circuit or device.

Instantaneous Value	The value of an alternating voltage or current at a given instant of time.
Insulated Wire	Conductor covered with a nonconductive material.
Insulation	A material which has a sufficiently high resistance to permit its use for separating one electrical circuit or wire from others.
Insulator	A medium which will not conduct electricity.
Intensity	Relative strength of electric or magnetic energy.
Interlock Switch	Safety switch which deenergizes voltage when doors, access covers or other openings are opened.
Internal Resistance	Resistance within a cell or battery to the flow of current.
Interpole	Placed between the main field poles of a DC motor or generator to reduce field distortion.
Inverter	A device which changes DC to AC. It consists of an AC generator driven by a DC motor.
Ion	A "charged" atom or molecule. One that has fewer or more electrons than normal.
Ionization	The process whereby a substance becomes ionized. Utilized in a gaseous tube to take advantage of the good current carrying characteristics of the ionized gas. Present when insulators break down.
Ionize	To make an atom lose an electron. The atom which loses the electron becomes a positive ion, the gaining atom is a negative ion.
Iron Core Coil	Coil in which iron forms part or all of the magnetic core, linking its windings.
Iron Loss	Power loss occurring in iron cores of electric machines, coils, transformers, etc., due to hysteresis and eddy currents.

-J-

Jack	A connecting device to which a wire or wires of a circuit may be connected.

-K-

Kilo (K)	One thousand.
Kilovolt-Amperes (KVA)	Volt amperes divided by 1,000. One KVA equals 1,000 volt amperes.

Kilowatt (KW)	Watts divided by 1,000. One KW equals 1,000 watts.
Kilowatt-Hours (KWH)	A measure of the consumption of electrical energy. The unit of electrical energy equal to 1,000 watts being consumed for one hour.

-L-

Lag	Of two alternating electrical quantities of the same frequency the one that reaches a particular cyclic point later is said to lag the other. This lag is expressed in electrical degrees.
Lagging Current	Current flowing in a circuit which lags voltage applied to the circuit.
Laminated	Made of thin layers.
Laminated Core	The core of an armature, transformer, etc, built up of stamping of sheets of iron which are insulated from each other to reduce eddy currents.
Law of Charges	Like charges repel; unlike charges attract.
Law of Electromagnetic Induction	(Faraday's Law) Electromotive force induced in a circuit is proportional to the change of the flux of magnetic induction linked with the circuit. When the change in flux linkage is caused by motion, relative to a magnetic field, of a conductor forming a part of an electric circuit, the electromotive force induced in the circuit is proportional to the rate at which the conductor cuts the flux of magnetic induction.
Law of Electrostatic Charges (Coulombs Law)	Force of attraction or repulsion between two charged bodies concentrated at two points in an isotropic medium is proportional to the produce of their magnitudes and is inversely proportional to the square of the distance between them.
Law of Magnetism	Like poles repel; unlike poles attract.
Lead (Material)	A term given to a wire or conductor.
Lead (Theoretical)	Of two alternating electrical quantities of the same frequency, the one that reaches a particular cyclic point first is said to lead the other. This is expressed in electrical degrees.
Leading Current	Current that reaches its maximum value before the voltage that produces it.
Leakage	Term used to express current loss through imperfect insulators.

Left-Hand Rule	For generators, stretch the thumb and first finger of the left hand at right angles to each other in the same plane and the second finger at a ninety degree angle perpendicular to the plane of the thumb and first finger. For a conductor in a generator armature, when the thumb indicates the direction of magnetic lines of force the second finger indicates the direction of electron flow. For a motor the right hand rule is used. For a current carrying wire, if the fingers of the left hand are closed around the wire so that the thumb points in the direction of electron flow, the fingers will be pointing in the direction of the magnetic field.
Lenz's Law	Whenever an induced current is produced by any motion, current will flow in a direction such that mechanical forces will be produced which oppose the motion.
Linear	Applied to meter scales, having equal graduations.
Line Drop	Voltage drop existing between two points of a power line due to resistance.
Lines of Force	Imaginary lines to indicate the direction and intensity of a magnetic or electrostatic field.
Line Voltage	Voltage level of the main power supplied to equipment.
Load	1. Power consumed by a machine or circuit in performing its function. 2. Resistor or other impedance which can replace some circuit element temporarily or permanently removed. 3. Power the machine or apparatus will deliver. 4. Device used to absorb power and convert it into the desired useful form. 5. Impedance to which energy is being supplied. 6. Power consuming device connected to circuit.
Loss	Amount of electrical attenuation in a circuit, or the power consumed in a circuit component. 2. Energy dissipated in accomplishing useful work; usually expressed in units of watts.

-M-

Magnet	A magnetic material which has the property of attracting or repelling other magnetic substances.
Magnetic Amplifier	A device using one or more saturable reactors to control the field strength of a generator.
Magnetic Circuit	The complete path of magnetic lines of force.
Magnetic Field	Space in which magnetic lines of force exist.

Magnetic Flux	The total flow of magnetic lines of force through a magnetic circuit.
Magnetic Flux Density	Magnetic field intensity measured in oersted.
Magnetic Lines of Force	Imaginary lines used for convenience to designate the direction in which magnetic forces are acting as a result of a magnetomotive force.
Magnetic Pole	The part of the magnet where the lines of force enter or leave the iron and where the forces of attraction and repulsion are concentrated.
Magnetic Saturation	The point of magnetization in an electromagnet where an increase in current causes no more increase in magnetism.
Magnetic Shield	Sheet or core of iron, enclosing instruments to protect them from stray magnetic fields by providing a convenient path for the magnetic lines of force.
Magnetism	The property of the molecules of certain substances, as iron, by virtue of which they may store energy in the form of a field of force and is due to the motion of the electrons in the atoms of the substance; a manifestation of energy due to the motion of a dielectric field of force.
Magnetomotive Force	That force which produces magnetic flux; measured in ampere-turns.
Matter	Anything which has weight and occupies space. It is found in three forms: solids, liquids, and gases.
Maximum Value	The greatest instantaneous value of an alternating current or voltage.
Meg or Mega	A prefix meaning one million times.
Megger	High range ohmmeter used for measuring insulation resistance values or other high resistances.
Megohm (MO)	A large unit of resistance; equal to one million ohms.
Mica	A mineral used for insulating purposes because of high dielectric strength and resistance to high temperatures.
Micro (µ)	A prefix meaning one-millionth of; designated by the Greek letter Mu.
Microfarad (µ f)	Practical unit of capacitance; one millionth of a farad.

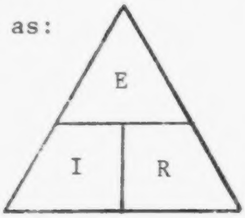
Micro-Micro (μ μ)	One millionth of one millionth.
Milli	A prefix meaning one thousandth.
Milliammeter	A meter calibrated in milliamperes.
Milliampere (ma)	A unit of current equal to one-thousandth of an ampere.
Molecule	The smallest particle of a substance which can exist and still retain all of the characteristics of that substance.
Molecular Theory of Magnetism	Assumption that each molecule of matter is a separate magnet and that in ferromagnetic materials these magnets all line up with their magnetic poles pointing in the same direction when the material is magnetized.
Motor	A machine which converts electrical energy into mechanical energy.
Motor Starter	A device for protecting electric motors from excessive current while they are reaching full speed.
Mu	Permeability, amplification factor, prefix micro.
Mutual Induction	See induction (mutual).

-N-

Negative	A term used to describe a terminal or point that has more electrons than normal; such as the negative terminal of a battery.
Negative Bias	A bias placing a negative charge on some tube element in respect to another tube element. Usually making the control grid negative in respect to the cathode.
Network	Special type of electric circuit which cannot be classified in terms of series and parallel parts.
Neutron	The small particle of an atom having no electric potential.
Nonlinear	In meters, a term used to express unequal graduations in the meter scale.
N-P-N Transistor	A transistor which consists of a thin slice of P-type semiconductor material sandwiched between two layers of N-type semiconductor.
N-P Semiconductor	See crystal diode.

Nucleus	Central part of the atom which makes up most of the weight of the atom. An atomic nucleus is made up of two kinds of fundamental particles, protons and neutrons. It has a positive charge equal to the number of protons it contains.

-0-

Ohm	The unit of electrical resistance. It is that value of electrical resistance through which a constant potential difference of 1 volt across the resistance will maintain a current flow of 1 ampere through the resistance.
Ohmic Value	Resistance in ohms.
Ohmmeter	An instrument used for measuring the resistance of a circuit.
Ohm's Law	The current in an electrical circuit is directly proportional to the electromotive force in the circuit. It is the fundamental law of electrical circuits and is true of all metallic circuits and most circuits containing an electrolyte resistance. The basic formula appears as: 
Ohmmeter Zero Adjustment	Potentiometer or other means provided to compensate for the reduction of battery voltage with age in an ohmmeter.
Open Circuit	1. Condition of an electrical circuit caused by the breaking of continuity of one or more of the conductors of the circuit; usually an undesired condition. 2. Circuit which does not provide a complete path for current to flow.
Oscilloscope	An instrument for showing, visually, graphical representations of waveforms encountered in electrical circuits.
Out-of-Phase	Having waveforms that are of the same shape but do not pass through corresponding values at the same instant.
Output	1. Current, voltage, power, or a driving force delivered by a circuit or device. 2. Terminals or other places where current, voltage, power, or other driving force may be delivered by a circuit or device.

Overload	Condition where the load on a circuit is greater than the rated load of the circuit. This causes excessive current flow on the circuit.
Overload Relay	A device which opens a circuit when the current exceeds a specified level.
Oxidation	The chemical process of combining with oxygen, often by exposure to air.

-P-

Parallel Circuit	An electrical circuit which has two or more paths for current to return to its source.
Parallel-Series	Circuit in which two or more parts are connected together in parallel to form parallel circuits and in which these circuits are then connected together in series so that both methods of connections appear.
Part	A mechanical unit which cannot readily be subdivided such as a tube, resistor.
Peak	Maximum instantaneous value of an alternating quantity.
Pentode	A five-element tube.
Period	Time required for the completion of one cycle.
Permanent Magnet	A magnet not dependent on a current for magnetization.
Permeability	The ability of a material to conduct magnetic lines of force, as compared to air.
Phase	The fraction of a cycle that has lapsed since a voltage or current has passed through a given cyclic point.
Phase Adapter	A device containing a coil and a capacitor for changing single-phase current into three-phase current.
Phase Difference	The relation between two sine wave quantities of the same frequency as to time that they pass a given cyclic point on their respective sine waves. The amount of time is expressed in electrical degrees.
Plate (P)	See anode.
Plate Voltage	The DC voltage applied between the plate and cathode of a vacuum tube.
P-N-P Transistor	A junction transistor formed by a slice of N-type semiconductor between two layers of P-type semiconductors.

Polarity	1. Condition of an electrical circuit by which the direction of current flow can be determined. Usually applied to batteries or other direct voltage sources. 2. Two opposite charges, one positive and one negative. 3. Quality of having two opposite magnetic poles, one North and one South.
Polyphase	Having more than one phase; as in three-phase.
Positive	A term used to describe a terminal having fewer electrons than another.
Positive Temperature Coefficient	Characteristic of a device or substance in which its resistance is directly proportional to changes in its temperature. (Temperature increases, its resistance also increases; temperature decreases, its resistance also decreases.)
Potential	Difference in voltage between two points of a circuit; frequently one is assumed to ground (zero potential). Generally expressed in volts.
Potential Barrier	Region in which the electric potential is such that moving electric charges attempting to pass through it encounter opposition and may be turned back.
Potential Difference	Algebraic difference between two points or individual potentials. Voltage existing between two points.
Potentiometer	A resistor which has a movable contact arm which can be set at any point of the resistor. The applied voltage is connected to the fixed end terminals of the resistor, and the output circuit is connected between the movable contact and one of the fixed terminals. Rotating the movable contact varies the proportion of the total voltage which is applied to the output circuit.
Power	Time rate of doing work or expending energy. In electrical systems, the basic unit is the watt.
Power Factor (PF)	The ratio expressed in percentage of actual power consumed in an AC circuit over apparent power.
Power Supply	Source of electrical energy required for normal operation of any electrical device or system.
Power Transformer	Transformer used to change the supply voltage to the various higher and lower values required for a system operation.
Primary	The first, in electrical order, of two or more coupled circuits, in which a change in current induces a voltage in the other or secondary circuit; such as the primary winding of a transformer. The primary is usually connected to the source of power.

Primary Current	Current flowing in the primary winding of a transformer.
Primary Voltage	Voltage applied to the primary windings of a transformer.
Proton	The particle in the nucleus of an atom having a positive charge.
Pulsating Direct Current	Current which varies in magnitude, but not in direction.
Pulsating Voltage	Varying voltage, the variations of which take place during regular intervals of time and may or may not include changes in polarity.
Pulse	A brief excursion of a quantity from normal; such as a pulsating voltage.
Pulse-per-second (pps)	The number of pulses of a pulsating voltage in a given length of time. Usually expressed as a frequency of a pulsating voltage.

-R-

Rate	Measurement of movement per unit of time; e.g., rate of flow, climb, etc.
Rated Output	Output power, voltage, or current, etc., at which a machine, apparatus, or device is designed to operate under specified normal conditions.
Reactance (X)	The opposition offered to the flow of an alternating current by the inductance, capacitance, or both in any circuit. Measured in ohms.
Reactive Load	Load having reactance, such as capacitive load or an inductive load, rather than a resistive load.
Reactive Power	Power given back in any circuit, by the collapsing magnetic field of an inductive reactor; or by the collapse of an electrostatic field of a capacitor or capacitive effect, or the combination thereof. Reactive power is generally expressed as volt-amperes-reactive (VAR) because the term "power" implies the expenditure of unrecoverable energy.
Rectification	The process of changing alternating current to direct current.
Rectifier	A device for converting alternating current to pulsating or full-wave direct current. Full-Wave Rectifier - A device which uses both positive and negative alternations of AC to produce a direct current.

Half-Wave Rectifier - A device which converts AC into pulsating DC by allowing current to pass during one alternation of each AC cycle.

Regulator, Carbon Pile	Device for controlling the voltage or current output of generators.
Regulator, Reg Ohm	Varies resistance in the control windings of the positive control mag amp.
Relay	An electromagnetic switch which permits control of a large current in one circuit by a much smaller current flowing in a control circuit.
Reluctance	Opposition to the flow of magnetic lines of force.
Residual Magnetism	The magnetism which remains in a material after the magnetizing force is removed.
Resistance (R)	The opposition to the flow of current caused by the nature and physical dimensions of a conductor.
Resistor	A circuit element whose chief characteristic is resistance; used to oppose the flow of current.
Resistance Wire	Wire made of a metal or alloy having high resistance per unit length, such as nichrome. Used in wire-wound resistors, heating elements, etc.
Retentivity	Ability to remain magnetized.
Rheostat	A variable resistor.
Right Triangle	A triangle which has one 90-degree angle.
Ripple	Periodic fluctuation on a DC voltage which results from incomplete filtering in a power rectifier set, or from the bars of the commutator of a DC generating machine.
Ripple Frequency	The number of pulses or ripples per unit length of time. It is used as an expression of the frequency of a pulsating voltage or current.
Rotor	The part of an electrical machine that turns or rotates.
Rotating Magnetic Field	Name applied to the magnetic field in the stator of AC motors.

-S-

Saturation	In a vacuum tube the condition which exists when an increase in plate potential does not increase electron flow of the tube.

Saturable Reactor	Magnetic core reactor in which a low value of current produces magnetic saturation of the core.
Schematic Circuit Diagram	Circuit diagram in which component parts are represented by simple, easily drawn symbols. May be called a schematic.
Secondary Coil	The output winding of a transformer.
Secondary Emission	The emission of electrons from the plate due to the bombardment of electrons from the cathode.
Secondary Voltage	Voltage across the secondary windings of a transformer.
Selenium Rectifier	Rectifier formed of discs of metal in contact with a layer of metallic selenium.
Self Excitation	A generator that receives excitation power from itself.
Self-Inductance	Induction associated with but one circuit.
Self-Induction	1. Action in which a counter electromotive force is produced in a conductor when the conductor's own magnetic field collapses and expands with a change of current flow. 2. Production of a voltage in a circuit as a result of a varying voltage in the same circuit.
Semiconductor	Solid or liquid electronic conductor, with resistivity between that of metals and insulators.
Semiconductor Diode	A diode made of semiconductor materials.
Series Circuit	Two or more units connected with only one path for current through them.
Shell	A group of electrons supposed to form part of the outer structure of the atom, and having a common energy level.
Short Circuit	A low or zero resistance path between two points. A type of electrical trouble wherein the current bypasses the normal unit of resistance in the circuit.
Shunt	A particular type of resistor designed to be connected in parallel with an instrument to extend its current range beyond the value for which the instrument is already complete.
Shunt Wound	A motor or generator wound so that the armature and field are in parallel.
Signal	Any transmitted electrical impulse.

Silicon	Nonmetallic element which is a semiconductor used in the manufacturing of transistors.
Sine Curve	The graph obtained by plotting the sine of an angle against degrees.
Sine Wave	The waveform of pure alternating current showing the buildup to maximum value and the falling off to zero of both negative and positive alternations.
Slip	The difference between synchronous speed and actual speed of the rotor of an induction motor.
Slip Rings	Copper rings which complete a circuit to a rotating member through brushes. May be used for either AC or DC circuits.
Solenoid	A coil of insulated wire wound in the form of a spring or on a spool.
Space Charge	A negative charge in a vacuum tube due to free electrons which are not attracted to the plate.
Specific Gravity	The ratio of the weight of a given volume of any substance to the weight of the same volume of pure water.
Spark	Flash due to an electric discharge through air or some other dielectric material, taking place between two or more electrodes.
Squirrel Cage Windings	Short circuited windings with its conductors joined by a continuous end ring.
Static	Fixed, nonvarying, non-moving condition.
Static Electricity	An electric charge caused by friction of two dissimilar materials, generally found in nature.
Stator	A stator is the part of an AC generator or motor which has the stationary winding on it.
Step-Down Transformer	Transformer in which the energy transfer is from a high voltage winding to a low voltage winding or windings.
Step-Up Transformer	A transformer in which the energy transfer is from a low voltage winding to a high voltage winding or windings.
Subatomic Particles	Particles which make up the atom. Proton, neutron and electron.
Switch (SW or S)	A device for closing, opening, or changing the connections of a circuit.

Switching	Making, breaking, or changing the electrical connections of a circuit.
Synchronization	The process of bringing two or more AC units in phase with each other.
Synchronous	Moving in perfect time or step.
Synchronous Motor	A motor which turns at the same speed as the rotating magnetic field.

-T-

Tap	A connection brought out of a winding of a transformer at some point between its extremities, usually to permit changing of the voltage ratio.
Terminal	A point to which electrical connections are made.
Test Jack	Appearance of a circuit or circuit element in jacks for testing purposes.
Test Lead	Flexible insulated lead used chiefly for connecting meters and test equipment to a circuit under test at a test point.
Test Prod	Sharp metal point provided with an insulated handle and means for electrical connection to a point under test. It is used for making touch connections to a circuit.
Thermocouple	A joint of two dissimilar metals across which a DC voltage is produced when heated.
Toggle Switch	A manually operated lever type switch.
Torque	A twisting or turning force.
Transformer (T)	A device for transferring electrical energy from one circuit to another. It may step up the voltage and step down the current or vice versa. In any particular case the total energy transferred remains the same, except for copper loss, eddy currents and hysteresis.
Transistor	Active semiconductor device with 3 or more electrodes.
Triode	A three-element vacuum tube.
True Power (P_t)	The power actually consumed in an AC circuit and equal to I^2R. Measured in watts.

Turn Ratio	The ratio of the number of turns in a primary winding of a transformer to the number of turns in the secondary winding.

-V-

Vacuum	An inclosed space from which practically all air has been removed. (A perfect vacuum is not obtainable.)
Valence	Measure of the extent to which an atom is able to combine directly with other atoms. It is believed to depend on the number and arrangement of the electrons in the outermost shell of the atom.
Valence Band	The range of energy states in the spectrum of a solid crystal in which lie the energies of the valence electrons which bind the crystal together.
Variable Capacitor	Capacitor whose capacitance can be varied from maximum to minimum value by mechanical means.
Variable Inductor	Coil in which the inductance value can be varied by mechanical means.
Variable Resistor	Wire-wound or composition resistor, the value of which can be changed by mechanical means.
Varmeter	Meter used to measure reactive power in an electrical circuit. Measures volt-amp-reactive; measures all of the volts of the circuit times all of the out-of-phase amps or current.
Vector	A line which by length shows amount of a quantity to scale and whose arrow represents direction or angle of the quantity.
Velocity	1. Quickness of motion; 2. speed.
Vibrator	A mechanical-electrical device used to change a continuous steady current into a pulsating current.
Volt (v)	Unit of electromotive force or electrical pressure. One volt is the pressure required to send 1 ampere of current through a resistance of 1 ohm.
Voltage	Term used to signify electrical pressure. Voltage is the force which causes current to flow through an electrical conductor. Voltage of a circuit is the greatest difference in potential between any two conductors of the circuit concerned.
Voltage Drop	A part of the applied voltage used up in a particular part of a circuit. In a simple circuit the voltage drop across the unit of resistance would equal the applied voltage.

Voltage Rating	The maximum sustained voltage that can be safely applied to an electrical device without risking the possibility of electrical breakdown.
Voltage Regulator	A device used in connection with generators to keep the output voltage constant as load or speed is changed.
Volt-Ampere (VA)	The unit of apparent power in an AC circuit.
Volt-Amp-Reactive (VAR)	The unit of reactive power; the product of the out-of-phase voltage and current.
Voltmeter	Instrument for measuring potential difference or voltage. It may be calibrated in volts, millivolts, or kilovolts.

-W-

Watt	Practical unit of electrical power. It is the power required to do work at the rate of 1 joule per second. In a DC circuit, the power in watts is equal to the voltage multiplied by the current in amperes. In an AC circuit, the true power in watts is the effective voltage multiplied by the circuit power factor. (Note) 746 watts = 1 horsepower.
Wattage Rating	Rating expressing the maximum power that a device can safely handle.
Wavelength	The distance between two corresponding phases of two consecutive waves of a wave train. It is usually expressed in meters.
Weight	The force with which a body is attracted toward the center of the earth by gravity.
Winding	One or more turns of wire forming a continuous coil for a transformer, rotating machine, or other device.
Wire	Solid or stranded group of solid, cylindrical conductors having low resistance to current flow, with any associated insulation.
Wire-wound Resistor	Resistor utilizing, as the resistive element, a length of high resistive wire or ribbon wound on an insulating form.
Wiring Diagram	Drawing that shows electrical equipment and/or component parts together with all the wiring that connects this equipment and/or parts.
Work	The result of a force acting, against opposition to produce motion and is measured in terms of the product of the force and the distance it acts.

Working Voltage	Voltage rating. In a capacitor it is the maximum that the device can withstand under normal operating conditions.
Wye	Method of connecting the stator windings in a 3 phase motor or generator.

-Z-

Zener Breakdown	In a semiconductor diode, a breakdown that is caused by the field emission of holes and electrons in the depletion layer.

77-43080

Environmental/Pneudraulic Branch
Chanute AFB, Illinois

3ABR42331-HO-101A
2 March 1981

COEFFICIENT HANDOUT

INFORMATION

This handout will provide you with some general information on coefficients for the automatic temperature control circuits for this career field. You will not be allowed to use this handout for any appraisal, progress check, performance test, measurement test or any form of an evaluation.

INSTRUCTIONS

After you receive this handout, place your name below with your class number. Before the fifth school day, you will color with a blue and red color the areas as instructed on each page. You are required to bring this handout with you each day to class until graduation.

The following is given to help define some of the areas on each of these four pages:

Bridge Circuit Wiring - Wiring in the bridge attached to the sensor. This wiring normally allows the sensor to be attached to the temp control box. In the temp control box you will find other parts of the bridge.

Temp Control Box - A container which may house micropositioners or magnetic amplifiers to receive signals from the sensor circuit which results in controlling power to the valve used for temperature control. This is where you will also find other parts of the bridge circuit.

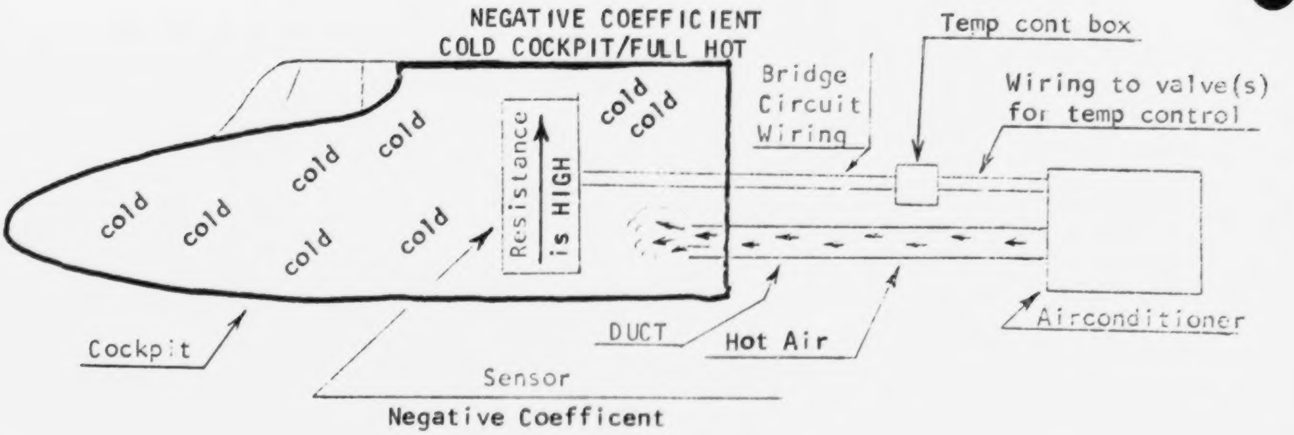
Wiring to valve(s) for temp control - Wiring used to carry the signal from the temp control box to the valve(s) for temperature control.

Sensor circuit - A circuit that includes a sensor and its wiring, which are normally found in a bridge circuit.

Name: Last First MI

Class Number

Supersedes 3ABR42331-HO-101D, 12 March 1980.
RGL: N/A
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; TTVSA - 1
Designed for ATC Course Use. Do Not Use on the Job.


NEGATIVE COEFFICIENT
COLD COCKPIT/FULL HOT
cold
Resistance
is HIGH
Bridge
Circuit
Wiring
Temp cont box
Wiring to valve(s)
for temp control
Cockpit
DUCT
Hot Air
Airconditioner
Sensor
Negative Coefficent

Color the duct between the air-conditioner and the cockpit red. Red = HOT AIR

Color the cockpit area where it is cold, blue. Blue = COLD AIR

A NEGATIVE coefficient sensor, as illustrated above, is surrounded by COLD AIR in the cockpit. This COLD AIR makes the sensor resistance go up (HIGH). A HIGH resistance in a NEGATIVE coefficient sensor calls for and gives the cockpit HOT AIR from the air-conditioner as shown above.

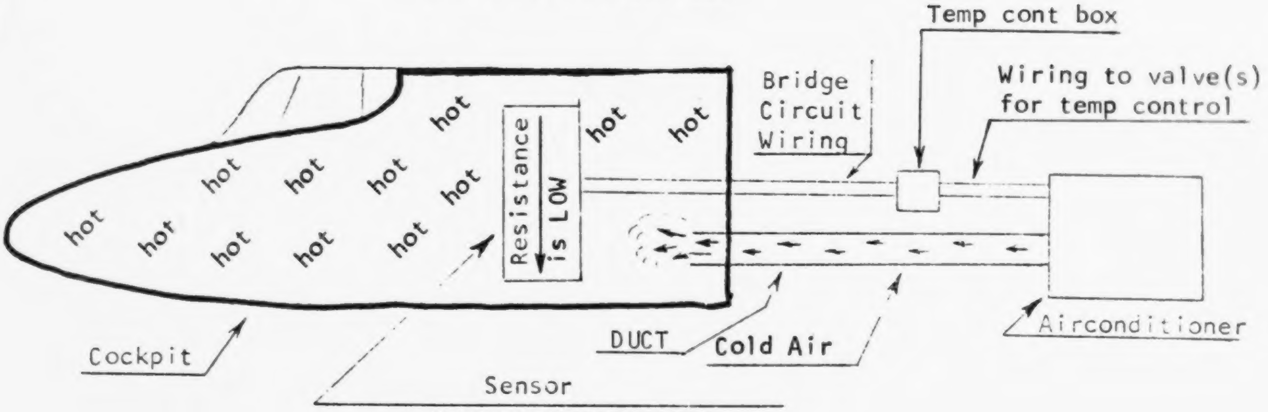
NOTE TO REMEMBER: The NEGATIVE coefficient SENSOR CIRCUIT in the BRIDGE is made up of the SENSOR, and the WIRING to the sensor.

Note: Remember, if the wiring in the bridge to the sensor is BROKEN (Open), as you should know by now from your multimeter training, there will be HIGH RESISTANCE. As you can see in the above information, HOT AIR will come from the air-conditioner anytime the NEGATIVE COEFFICIENT CIRCUIT (in the bridge) has a HIGH RESISTANCE in it. This is caused either by a HIGH RESISTANCE or an OPEN in the SENSOR or WIRING.

REMEMBER REMEMBER REMEMBER REMEMBER REMEMBER REMEMBER

REMEMBER: HIGH RESISTANCE in a NEGATIVE COEFFICIENT sensor circuit (in the bridge) gives the cockpit HOT AIR from the air-conditioner.

NEGATIVE COEFFICIENT
HOT COCKPIT/FULL COLD


Temp cont box
Bridge
Circuit
Wiring
Wiring to valve(s)
for temp control
hot
Resistance
is LOW
Cockpit
DUCT
Cold Air
Airconditioner
Sensor

NEGATIVE COEFFICIENT

Color the duct between the air-conditioner and the cockpit blue. Blue = COLD AIR

Color the cockpit area where it is hot red. Red = HOT AIR

A NEGATIVE coefficient sensor, as illustrated above, is surrounded by HOT AIR in the cockpit. This HOT AIR makes the sensor resistance go down (LOW). A LOW resistance in a NEGATIVE coefficient sensor calls for and gives the cockpit COLD AIR from the air-conditioner as shown above.

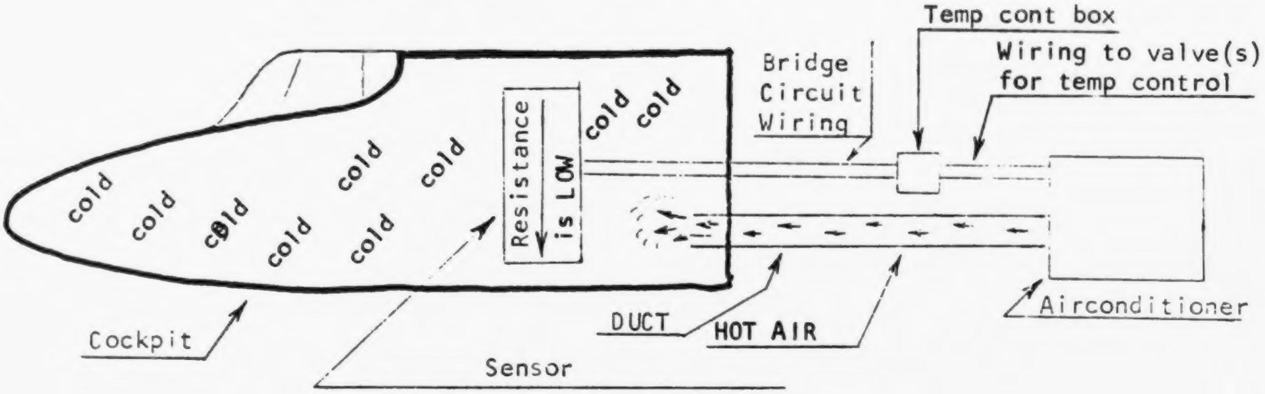
NOTE TO REMEMBER: The NEGATIVE coefficient SENSOR CIRCUIT in the BRIDGE is made up of the SENSOR, and the WIRING to the sensor.

Note: Remember, if the wiring in the bridge to the sensor is SHORTED, there will be a LOW RESISTANCE. As you can see in the above information, COLD AIR will come from the air conditioner anytime the NEGATIVE COEFFICIENT CIRCUIT (in the bridge) has a LOW RESISTANCE in it. This is caused either by a LOW RESISTANCE or a SHORT in the SENSOR or WIRING.

REMEMBER REMEMBER REMEMBER REMEMBER REMEMBER REMEMBER

REMEMBER: LOW RESISTANCE in a NEGATIVE COEFFICEINT sensor circuit (in the bridge) gives the cockpit COLD AIR from the air-conditioner.

POSITIVE COEFFICIENT
COLD COCKPIT/FULL HOT


Temp cont box
Bridge Circuit Wiring
Wiring to valve(s) for temp control
Resistance is LOW
cold
Cockpit
DUCT
HOT AIR
Airconditioner
Sensor

POSITIVE COEFFICIENT

Color the duct between the air-conditioner and the cockpit red. Red = HOT AIR

Color the cockpit area where it is cold blue. Blue = COLD AIR

A POSITIVE coefficient sensor, as illustrated above, is surrounded by COLD AIR in the cockpit. This COLD AIR makes the sensor resistance go down (LOW). A LOW resistance in a POSITIVE coefficient sensor calls for and gives the cockpit HOT AIR from the air-conditioner as shown above.

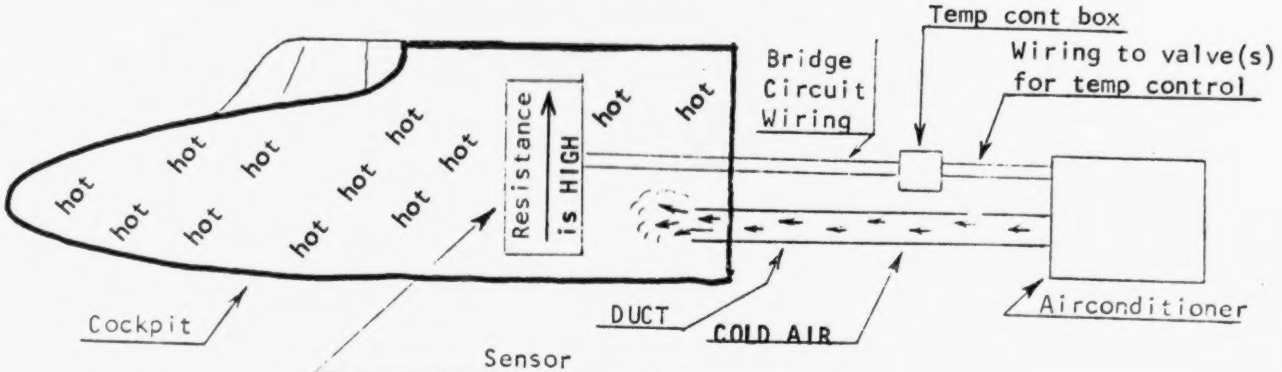
NOTE TO REMEMBER: The POSITIVE coefficient SENSOR CIRCUIT in the BRIDGE is made up of the SENSOR, and the WIRING to the sensor.

Note: Remember, if the wiring in the bridge to the sensor is SHORTED, there will be a LOW RESISTANCE. As you can see in the above information, HOT AIR will come from the air-conditioner anytime the POSITIVE COEFFICIENT CIRCUIT (in the bridge) has a LOW RESISTANCE in it. This is caused either by a LOW RESISTANCE or a SHORT in the SENSOR or WIRING.

REMEMBER REMEMBER REMEMBER REMEMBER REMEMBER REMEMBER

REMEMBER: LOW RESISTANCE in a POSITIVE COEFFICIENT sensor circuit (in the bridge) gives the cockpit HOT AIR from the air-conditioner.

POSITIVE COEFFICIENT
HOT COCKPIT/FULL COLD


Temp cont box
Bridge Circuit Wiring
Wiring to valve(s) for temp control
hot
Resistance is HIGH
Cockpit
DUCT
COLD AIR
Airconditioner
Sensor

POSITIVE COEFFICIENT

Color the duct between the air-conditioner and the cockpit blue. Blue = BLUE AIR

Color the cockpit area where it is hot red. Red = HOT AIR

A POSITIVE coefficient sensor, as illustrated above, is surrounded by HOT AIR in the cockpit. This HOT AIR makes the sensor resistance go up (HIGH). A HIGH resistance in a POSITIVE coefficient sensor calls for and gives the cockpit COLD AIR from the air-conditioner as shown above.

NOTE TO REMEMBER: The POSITIVE coefficient SENSOR CIRCUIT in the BRIDGE is made up of the SENSOR, and the WIRING to the sensor.

Note: Remember, if the wiring in the bridge to the sensor is BROKEN (open), there will be a HIGH RESISTANCE. As you can see in the above information, COLD AIR will come from the air-conditioner anytime the POSITIVE COEFFICIENT CIRCUIT (in the bridge) has a HIGH RESISTANCE in it. This is caused either by a HIGH RESISTANCE or a OPEN in the SENSOR or WIRING.

REMEMBER REMEMBER REMEMBER REMEMBER REMEMBER REMEMBER

REMEMBER: HIGH RESISTANCE in a POSITIVE COEFFICIENT sensor circuit (in the bridge) gives the cockpit COLD AIR from the air-conditioner.

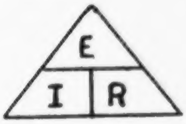
Environmental/Pneudraulic Branch
Chanute AFB, Illinois

3ABR42331-HO-101B
26 October 1981

RULES, LAWS AND FORMULAS

$^\circ C = \frac{^\circ F - 32}{1.8}$ $^\circ F = ^\circ C \times 1.8 + 32$

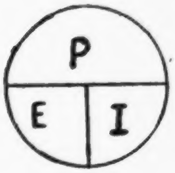
Ohm's Law



$E = I \times R$

$I + E/R$

$R = E/I$



$P = I \times E$

$E = P/I$

$I = P/E$

Kirchoff's Laws

Current - The sum of the current flowing into any junction of conductors, is equal to the sum of the currents flowing away from the junction.

Voltage - The sum of the voltage drops around any closed paths, is equal to the applied voltage.

Resistance -

Series

$R_t = R_1 + R_2 + R_3$ etc.

Parallel

$$R_t = \frac{1}{1/R_1 + 1/R_2 + 1/R_3 \text{ etc.}}$$

Open Circuit - incomplete path for current flow.

Short Circuit - also called a short. An abnormal connection of relatively low resistance between two points of a circuit. The result is a flow of excess (often damaging) current between these points.

Supersedes 3ABR42331-HO-101B, 20 February 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; DAV - 1

RGL: N/A

Designed for ATC Course Use. Do Not Use on the Job.

Environmental/Pneudraulic Branch
Chanute AFB, Illinois

3ABR42331-HO-101C
15 January 1981

ORIENTATION HANDOUT

Student Name________________________________ Date____________________
Last First MI

Chain of Command

SQ Commander____________________ Ph________
Branch Chief____________________ Ph________
Course Sup ____________________ Ph________
Blk Sup
Blk I ____________________ Ph________
Blk II ____________________ Ph________
Blk III ____________________ Ph________
Blk IV ____________________ Ph________
Student Sup____________________ Ph________

Course # __________
Class # __________
Graduation # __________

Class Time for Blk ______
Class Start ______
Class Over ______
Lunch Time ______
Breaks _____to_____
_____to_____
_____to_____
_____to_____
_____to_____
_____to_____
_____to_____
_____to_____
_____to_____

Clean-up time, last 20 min of the day.

Block I Fundamentals

Measurement I	47.5 Hrs	6.1 Days
Measurement II	81.0 Hrs	10.7 Days
Total	129.0 Hrs	16.8 Days
+ MT	24.0 Hrs	---Military Training

Block II Air Conditioning Systems

Measurement I	61.5 Hrs	8.0 Days
Measurement II	67.5 Hrs	8.8 Days
Total	129.0 Hrs	16.8 Days
+ MT	6.0 Hrs	

Block III Environmental Systems Units

Measurement I	83.0 Hrs	10.9 Days
Measurement II	50.0 Hrs	6.5 Days
Total	133.0 Hrs	17.4 Days
+ MT	8.0 Hrs	

Block IV Utility Systems and Flight Line Maintenance

Measurement I	76.5 Hrs	10.0 Days
Measurement II	40.0 Hrs	5.0 Days
Total	116.5 Hrs	
+ MT	14.0 Hrs	
+ Critique and Grad.	0.5 Hrs	
Total	507.0 Hrs	= 66.0 Days = 13 Weeks
+	52.0 Hrs	
+ Critique and Grad.	0.5 Hrs	
Total	560.0 Hrs	

EMERGENCY PHONE NUMBERS
Dial 117 for fire

Dial "CARE" or 2273 anytime for personal problems.

8 hrs in class = 1 Day of school
40 Hrs in Class = 1 Week of school
Orientation Day in school counts for your first day of school.
Satisfactory completion of course with a diploma, CCAF will give _____ semester hours toward an associate degree in applied science degree in the Environmental and Ejection Systems Technology

Class start and stop policies at ________ and __________.

__ Student must be in their class or lab no later than __________ hrs.

__ Student will not leave the school or building before ________ hrs without an instructor or instructor supervisors permission.

__ Student will meet the squadron formation after ____ as directed by squadron and/ or school, excluding the SIA students.

__ SIA students will be dismissed at ____ and return to squadron.

__ Students will not linger around the school building during lunch.

__ Students are asked not to return any earlier than _____ hrs to the school building.

__ Students will _________ to and from the chow hall during the lunch period.

__ Students will be in their class or lab no later than _____ hrs after lunch.

__ Students will be dismissed at ____ hrs for lunch and may leave for lunch starting at ________ hrs.

PROGRAMMED TEXT

C3ABR42331-PT-105

Technical Training

Aircraft Environmental Systems Mechanic

AIRCRAFT FAMILIARIZATION

20 October 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL. 10.6

OBJECTIVES

1. Specify elements used to make up the aircraft designation system with a minimum of 80% accuracy.

2. Specify the terms of the aircraft station numbering system with a minimum of 80% accuracy.

3. Relate major aircraft systems to their purpose with a minimum of 80% accuracy.

Supersedes 3ABR42331-PT-105, 26 March 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

INSTRUCTIONS

Use the response sheet and place all your answers on it. DO NOT WRITE IN THIS BOOK. This program presents information in sections:

SECTION I, Aircraft Designation System

SECTION II Aircraft Station Numbering System

SECTION III, Major Aircraft Systems

In each section you will find the program presents the information in small steps called "FRAMES." After reading each frame, you are normally asked to select an answer or make an entry that shows you understand the information in that frame. Check the accuracy of your work with the answers supplied at the end of each section. If you responded incorrectly, find out why you missed the question. You can do this by reaccomplishing the frame or the section. If you still continue to have incorrect responses consult your instructor. Insure you have taken corrective measures for your incorrect responses before you move on to the next frame, section, test, or text. If you have correctly responded, continue working as directed in the program.

After completion of this program text response sheet (all three sections) consult your instructor so you may be given the test on this program.

Now turn to SECTION I, Frame 1 and begin.

SECTION I

AIRCRAFT DESIGNATION SYSTEM

FRAME 1

The designation system described in this section applies to all military aircraft (fixed, movable, and rotary wing) with a combat or combat-related mission. Hereafter, military aircraft included in the designation system may be referred to collectively as aerospace vehicles.

On the response sheet place "T" for true and "F" for false for the following.

____ 1. The designation system is not for combat-related aircraft.

____ 2. Combat aerospace vehicles will have the designation system.

AIRCRAFT

DEFINITION - An air vehicle designed primarily for flight in the atmosphere which has incorporated in its basic design the ability or requirement for human occupancy.

On the response sheet place "T" for true and "F" for false for the following.

____ 1. An aircraft will always have the requirement for human occupancy.

FRAME 3

EXAMPLE ——→ G R 3 - 52 A 01

BASIC DESIGNATION ——↑

DEFINITION - The minimum combination of letters and numbers required to identify adequately an aerospace vehicle.

On the response sheet place "T" for true and "F" for false for the following.

____ 1. Letters are the only things used to identify adequately an aerospace vehicle.

AEROSPACE VEHICLE DESIGNATION SYSTEM

All military aerospace vehicles will be assigned a basic designation consisting of items listed in Frame 5 through Frame 10, as applicable, in the order shown.

NO RESPONSE REQUIRED

GO TO NEXT FRAME

FRAME 5

EXAMPLE ——► G R B - 52 A 01

STATUS PREFIX SYMBOL

This symbol (letter), if it is applicable, indicates an aerospace vehicle which is not standard due to test instrumentation, modification, experiment 1, or prototype design. For aircraft, the symbol will be placed at the immediate left of the modified mission symbol or the basic mission symbol in the absence of the former. Attachment 1 gives the authorized status prefix symbols, at the end of this section. Turn to attachment 1 and find the letter, the title and the description which are used for status prefix symbols.

Without looking in attachment 1, on your response sheet mark the correct answer for the following.

1. The status prefix symbol "G" shown in the example above has the title,

   a. permanently grounded.

   b. experimental.

   c. prototype.

   d. planning.

2. Experimental aerospace vehicles will use which letter for status prefix symbols?

   a. J

   b. N

   c. X

   d. Y

FRAME 6

EXAMPLE ——→ G R B - 52 A 01

MODIFIED MISSION SYMBOL ——→ R

This symbol will consist of a prefix letter placed at the immediate left of the basic mission of the aircraft. Normally, only one modified mission symbol will be used for any one designation. Attachment 2 gives the authorized modified mission symbols at the end of this section. Turn to attachment 2 and find the letter, the title and the description which are used for modified mission symbols.

Without looking in attachment 2, on your response sheet mark the correct answer for the following.

1. The modified mission symbol "R" shown in the example above has the title,

   a. special electronic installation.

   b. reconnaissance.

   c. transport.

   d. rescue.

2. An aerospace vehicle will use which modified mission symbol letter to identify an tanker?

   a. C

   b. P

   c. K

   d. T

On the response sheet mark "T" for true and "F" for false for the following.

3. _______ The example given above tells you the aircraft has been modified to a reconnaissance aircraft and also has been permanently grounded.

FRAME 7

EXAMPLE → G R B - 52 A 01

BASIC MISSION AND TYPE SYMBOLS

The basic mission symbol (letter) denotes the primary function of capability of an aircraft. Mission and type symbols denote the mission and type of aircraft other than fixed wing. An aircraft identified by a type symbol such as "H" for helicopter will be further identifed by either a mission symbol or a modified mission symbol, but not both. Attachment 3 gives the authorized basic mission and type symbols at the end of this section. Turn to attachment 3 and find the letter, title, and the description which are used for basic mission and type symbols.

Without looking in attachment 3, on your response sheet mark the correct answer for the following.

1. The basic mission and type symbol "B" shown in the example above has the title,

   a. attack.

   b. bomber.

   c. tanker.

   d. transport.

2. An aerospace vehicle will use which basic mission and type symbol letter to identify a tanker?

   a. C

   b. K

   c. T

   d. X

On the response sheet mark "T" for true and "F" for false for the following.

3. _____ The example given above tells you the aircraft was a bomber and has been modified to a reconnaissance mission and has been permanently grounded.

FRAME 8

EXAMPLE → G R B - 52 A 01

DESIGN NUMBER

This number gives changes that are within the same basic aerospace vehicle. Design numbers will be assigned consecutively beginning with "1" for each vehicle. A dash will be placed between the basic mission symbol and the design number for all aerospace vehicles.

The above example shows this was originally a B-52 (bomber) aircraft which is the 52nd design number.

Examples:

B-1, B-2, B-3 -----, B-24, B-25, ----, B-52, ----, B-58, -- B-66, etc.

On the response sheet mark "T" for true or "F" for false for the following.

____ 1. The example given below tells you the aircraft was a bomber and modified to refueling aircraft and has been permanently grounded and also is the 52nd tanker in the design number sequence.

EXAMPLE: G R B - 52 A 01

FRAME 9 EXAMPLE ——→ G R B - 52 A 01

SERIES SYMBOL ————————————————↑

A letter that is after the design number shows the initial production model and follow-on major modifications to an aerospace vehicle. This change is made when it results in a significant difference that affects the relationship of the vehicle to the original aircraft production mode. Series symbol letters will be assigned consecutively, beginning with "A." To avoid confusion, the letters "I" and "O" will not be used as series letters.

Example:

B-52A, B-52B ---- B-52E, B-52F, B-52G, B-52H, ---- etc.

C-130A, C-130B ----- C-130E, ---- C-130J, C-130K, --- etc.

On your response sheet mark the correct answer for the following.

1. In the example GRC - 24D01 which letter is the series symbol?

   a. G

   b. R

   c. C

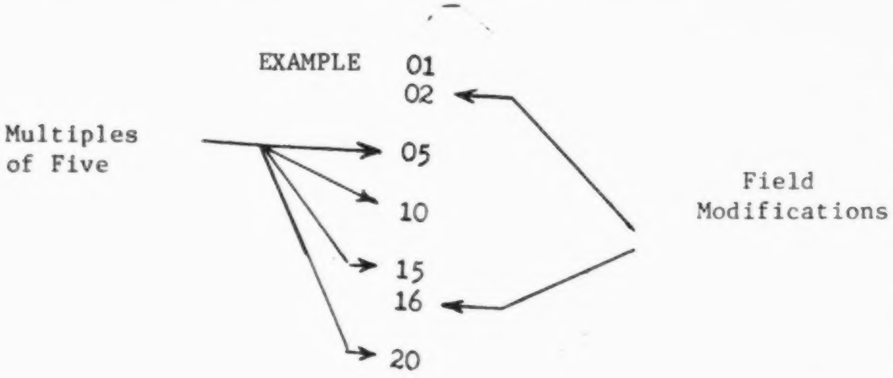
   d. D

FRAME 10

EXAMPLE → G R B - 52 A 01

BLOCK NUMBERS

The production block numbering system will be made up of the assignment of production blocks, starting at 01, next 05, and progression in multiples of five after 05. Intermediate block numbers will be reserved for field modifications and will be applied by the using military department.



On your response sheet mark the correct answer for the following.

1. The block number in the aircraft designation GRB-52G23 shows that the

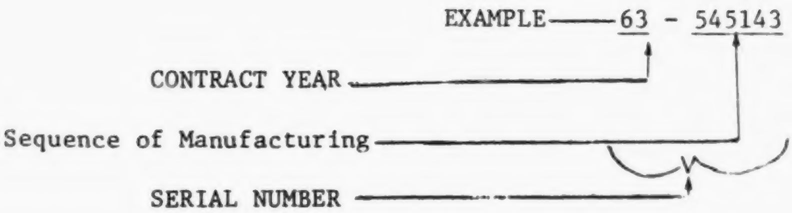
   a. production block number is "20" and the intermediate block number for field modifications is "23."

   b. production block number is "23" and the intermediate block number for field modifications is "03."

   c. production block number is "52" and the intermediate block number for field modifications is "02."

   d. production block number is "52" and the intermediate block number for field modifications is "23."

FRAME 11


EXAMPLE 63 - 545143
CONTRACT YEAR
Sequence of Manufacturing
SERIAL NUMBER

The method of assigning serial numbers is at the discretion of the using military department. As shown in the above example the first two numbers in front of the dash is the contract year of the aircraft. The group of numbers to the right of the dash is the number assigned in the sequence of manufacturing the aircraft.

On the response sheet mark "T" for true or "F" for false for the following.

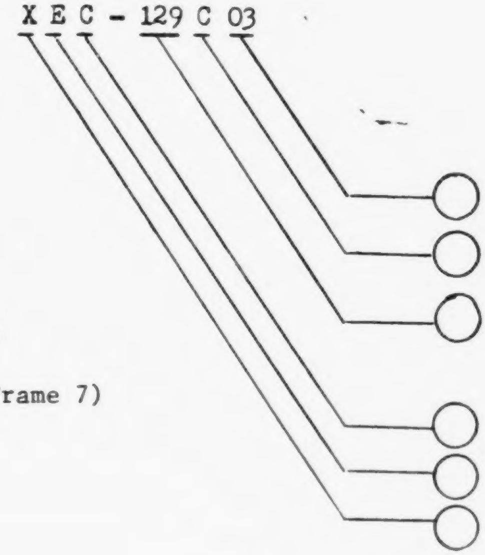
1. _____ The contract year is not part of the aircraft serial number.

FRAME 12

Identify each part of the aircraft designation given below. You will do this by selecting the correct identification in column 1, then write its letter in the correct circle under the aircraft designation. DO NOT WRITE ON THIS PAGE. You are to do this work on the response sheet.

Column 1

- a. Block numbers (Frame 10)
- b. Design number (Frame 8)
- c. Series symbol (Frame 9)
- d. Status prefix symbol (Frame 5)
- e. Modified mission symbol (Frame 6)
- f. Basic mission and type symbols (Frame 7)

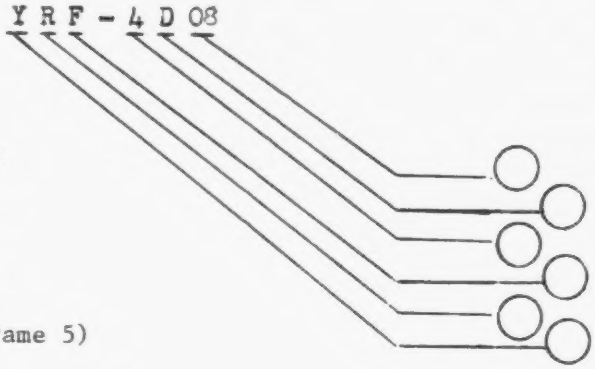


Note: If you make an error study the required frames as needed before you go to frame 13.

FRAME 13

If you have made an error on frame 12 be sure you restudy the required frame(s) before you start this frame.

Identify each part of the aircraft designation given below. You will do this by selecting the correct identification in column 1, then write its letter in the correct circle under the aircraft designation. DO NOT WRITE ON THIS PAGE. You are to do this work on the response sheet.



Column 1

a. Block numbers (Frame 10)

b. Design number (Frame 8)

c. Series symbol (Frame 9)

d. Status prefix symbol (Frame 5)

e. Modified mission symbol (Frame 6)

f. Basic mission and type symbols (Frame 7)

Note: If you make an error in this frame you should go back and restudy frames 1 through 13.

After finishing frames 1 through 13 correctly go on to SECTION II.

STATUS PREFIX SYMBOLS

AEROSPACE VEHICLES

LETTER	TITLE	DESCRIPTION
G*	Permanently Grounded	Aircraft permanently grounded and utilized for ground instruction and training.
J	Special Test, Temporary	Aerospace vehicles on special test programs by authorized organizations or on bailment contract having a special test configuration or whose installed property has been temporarily removed to accommodate the test.
N	Special Test, Permanent	Aerospace vehicles on special test programs by authorized activities or on bailment contract, whose configuration is so drastically changed that return to its original configuration or conversion to standard operational configuration is beyond practicable or economical limits.
X	Experimental	Aerospace vehicles in a development experimental stage where the basic mission symbol and design number have been designated, but not established as a standard vehicle.
Y	Prototype	Aerospace vehicles procured in limited quantities, usually before production decision, to serve as models or patterns.
Z	Planning	Aerospace vehicles in the planning or predevelopment stage.

---

*Applies only to aircraft

Attachment 1

MODIFIED MISSION SYMBOLS

AIRCRAFT

LETTER	TITLE	DESCRIPTION
A	Attack	Aircraft modified to search out, attack, and destroy enemy land or sea targets, using conventional or special weapons. This symbol also describes aircraft used for interdiction and close air support missions.
C	Transport	Aircraft modified for the carriage of personnel or cargo.
D	Director	Aircraft modified for controlling drone aircraft or a missile.
E	Special Electronic Installation	Aircraft modified with electronic devices for employment in one or more of the following missions: (1) Electronic countermeasures. (2) Airborne early warning radar. (3) Airborne command and control, including communications relay. (4) Tactical data communications link for all nonautonomous modes of flight.
H	Search Rescue	Aircraft modified and equipped for performance of search and rescue missions.
K	Tanker	Aircraft modified and equipped to provide in-flight refueling of other aircraft.
L	Cold Weather	Aircraft modified for operation in the Arctic and Antarctic regions; includes skis, special insulation, and other ancillary equipment required for extreme cold weather operations.
M	Mine Countermeasures	Aircraft modified for aerial mine countermeasures and minesweeping missions.
O	Observation	Aircraft modified to observe (through visual or other means) and report tactical information concerning composition and disposition of enemy forces, troops, and supplies in an active combat area.
P	Patrol	Long-range, all-weather, multi-engine aircraft operating from land and/or water bases modified for independent accomplishment of: antisubmarine warfare; maritime reconnaissance; and mining function.
Q	Drone	Aircraft modified to be controlled from a point outside the aircraft.
R	Reconnaissance	Aircraft modified and permanently equipped for photographic or electronic reconnaissance missions.
S	Antisubmarine	Aircraft modified so that it can function to search, identify, attack and destroy enemy submarines.
T	Trainer	Aircraft modified and equipped for training purposes.
U	Utility	Aircraft modified for a capability of performing multiple missions such as battlefield support, localized transport, and special light missions. These aircraft will include those having a small payload.
V	Staff	Aircraft modified to provide accomodations such as chairs, tables, lounge, berths, etc., for transporting staff personnel.
W	Weather	Aircraft modified and equipped for meteorological missions.

Note: Above you will find the most common titles underlined.

Attachment 2

BASIC MISSION AND TYPE SYMBOLS

AIRCRAFT

LETTER	TITLE	DESCRIPTION
A	Attack	Aircraft designed to search out, attack, and destroy enemy land or sea targets, using conventional or special weapons. This symbol also applies to aircraft used for interdiction and close air support missions.
B	Bomber	Aircraft designed for bombing enemy targets.
C	Transport	Aircraft designed primarily for carrying personnel or cargo.
E	Special Electronic Installation	Aircraft equipped with electronic devices for employment in one or more of the following missions: (1) Electronic countermeasures. (2) Airborne early warning radar. (3) Airborne command control including communications relay. (4) Tactical data communications link for all nonautonomous modes of flight.
F	Fighter	Aircraft designed to intercept and destroy other aircraft and/or missiles (includes multipurpose aircraft also designed for ground support missions), for example, interdiction and close air support.
H*	Helicopter	Rotary-wing aircraft designed with the capability of flight in any plane, for example, horizontal, vertical, or diagonal.
K	Tanker	Aircraft designed for in-flight refueling of other aircraft.
O	Observation	Aircraft designed to observe (through visual or other means) and report tactical information concerning composition and disposition of enemy forces, troops, and supplies in an active combat area.
P	Patrol	Long-range, all-weather, multiengine aircraft operating from long and/or water bases designed for independent accomplishment of: antisubmarine warfare; maritime reconnaissance; and mining function.
R	Reconnaissance	Aircraft designed to perform reconnaissance missions.
S	Antisubmarine	Aircraft designed to search out, detect, identify, attack, and destroy enemy submarines.
T	Trainer	Aircraft designed for training personnel in the operation of aircraft or related equipment, and having provisions for instructor personnel.
U	Utility	Aircraft designed with a capability of performing multiple missions such as battlefield support, localized transport, and special light missions. These aircraft will include those having a small payload.
V*	VTOL and STOL	Aircraft designed for vertical takeoff or landing with no takeoff or landing roll, or aircraft capable of takeoff and landing in a minimum prescribed distance.
X	Research	Aircraft designed for testing configuration of a radical nature. These aircraft are not normally intended for use as tactical aircraft.

---

* Type Symbols

Note: Above you will find the most common titles underlined.

CORRECT RESPONSES FOR SECTION I

Frame 1

1. F
2. T

Frame 2

1. F

Frame 3

1. F

Frame 4

No response

Frame 5

1. a
2. c

Frame 6

1. b
2. c
3. T

Frame 7

1. b
2. b
3. T

Frame 8

1. F

Frame 9

1. d

Frame 10

1. a

Frame 11

1. F

Frame 12

a

c

b

f

e

d

Frame 13

a

c

b

f

e

d

SECTION II

AIRCRAFT STATION NUMBERING SYSTEM

Frame 1

This part of the lesson will be spent on the station numbering system.

Military aircraft have become so large and have so much equipment that it has become necessary to make a system for locating the various units. No doubt, you are familiar with the way most cities are laid out with two dividing streets intersecting each other ar right angles in the heart of the city. Any point in the city can be located with reference to these two lines. The same principle is used in locating parts of an aircraft except that a third reference line is needed because the aircraft has three dimensions, namely, length, width, and height. Diagrams of the station numbering system, as well as the terms used in the system, are shown and defined in the following frames.

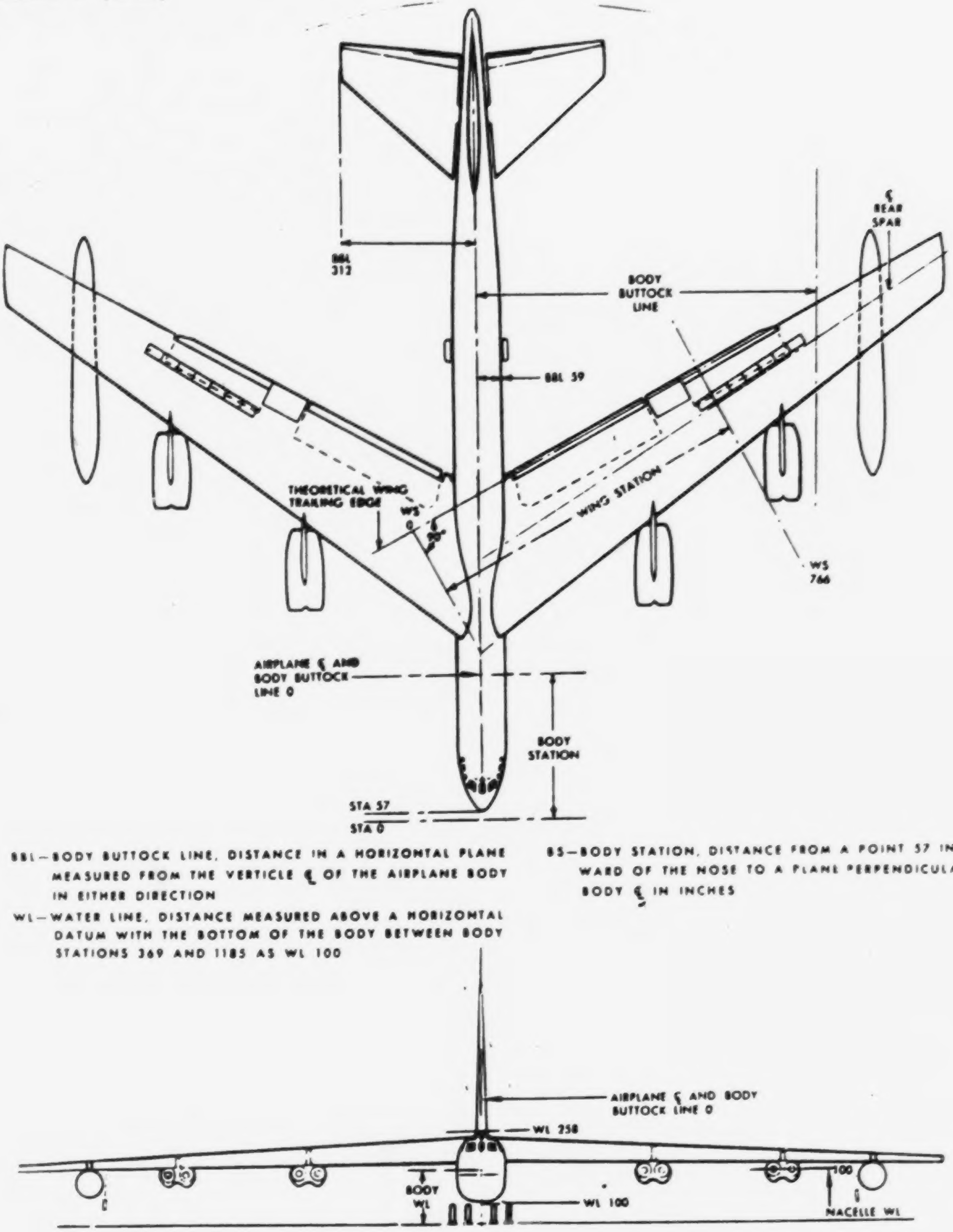
On the response sheet write the correct answer for the following.

The purpose of the station number system is to:

a. aid in the location of various parts or units.
b. aid in the use of the data collection system.
c. be used in the number sequencing of aircraft.
d. aid in the identification of types of aircraft.

Frame 1 (cont)

ILLUSTRATION FOR FRAME 1


BBL 312
BODY BUTTOCK LINE
℄ REAR SPAR
BBL 59
THEORETICAL WING TRAILING EDGE
WS 0
90°
WING STATION
WS 766
AIRPLANE ℄ AND BODY BUTTOCK LINE 0
BODY STATION
STA 57
STA 0
AIRPLANE ℄ AND BODY BUTTOCK LINE 0
WL 258
BODY WL
WL 100
100
NACELLE WL

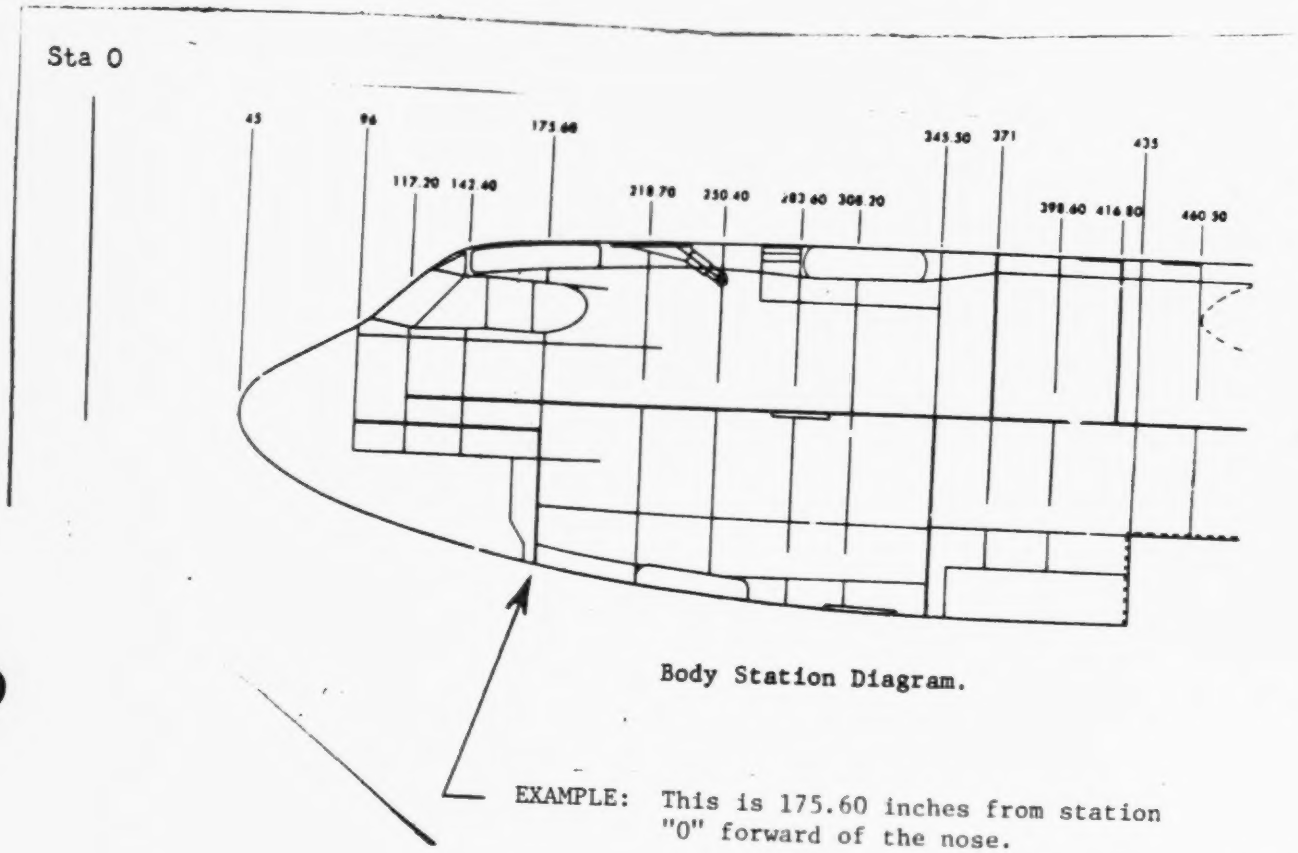
BBL—BODY BUTTOCK LINE, DISTANCE IN A HORIZONTAL PLANE MEASURED FROM THE VERTICLE ℄ OF THE AIRPLANE BODY IN EITHER DIRECTION

WL—WATER LINE, DISTANCE MEASURED ABOVE A HORIZONTAL DATUM WITH THE BOTTOM OF THE BODY BETWEEN BODY STATIONS 369 AND 1185 AS WL 100

BS—BODY STATION, DISTANCE FROM A POINT 57 INCHES FORWARD OF THE NOSE TO A PLANE PERPENDICULAR TO THE BODY ℄ IN INCHES

Airplane Station Nomenclature Diagram

Frame 2


Sta 0
45
96
117.20
142.40
175.60
218.70
250.40
283.60
308.20
345.50
371
398.60
416.80
435
460.50

Body Station Diagram.

EXAMPLE: This is 175.60 inches from station "0" forward of the nose.

Body stations (BS) are distances measured in inches from a point forward of the nose (STA 0) aft along the fuselage to the tail of the aircraft. These stations are planes cutting through the fuselage at right angles, which are then numbered. The number of a station tells how many inches it is from station 0. The station 0 being forward of the nose allows for aircraft to be lengthened without changing the station numbering system.

Frame 2 (cont)

On the response sheet mark the correct answer for the following.

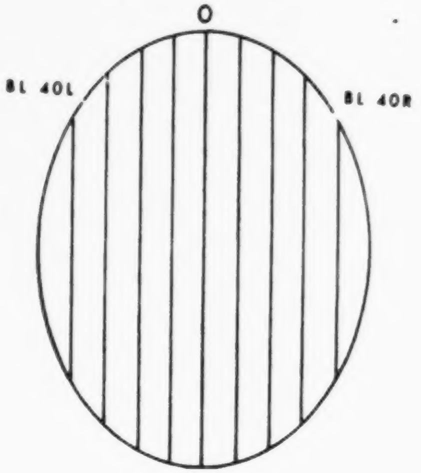
1. Distances from a point forward of the nose of an aircraft aft along the fuselage to the tail, are called

    a. water lines (WSs).
    b. body buttock lines (BBLs).
    c. body stations (BSs).
    d. reference datum lines (RDLs).

2. Body station number 180 means that

    a. station is 180 inches from previous station.
    b. station is 180 inches from tail section of the aircraft.
    c. station is 180 inches from station "0."
    d. 180 is just any number assigned with no additional meaning.

Body buttock lines (BBLs) are distances measured in inches, right and left from the vertical centerline of the fuselage. These lines run parallel to the vertical centerline and are numbered just as fuselage body stations are numbered. Those on the left of the centerline are indicated by the letter "L" and those on the right by the letter "R."



Body Buttock Lines.

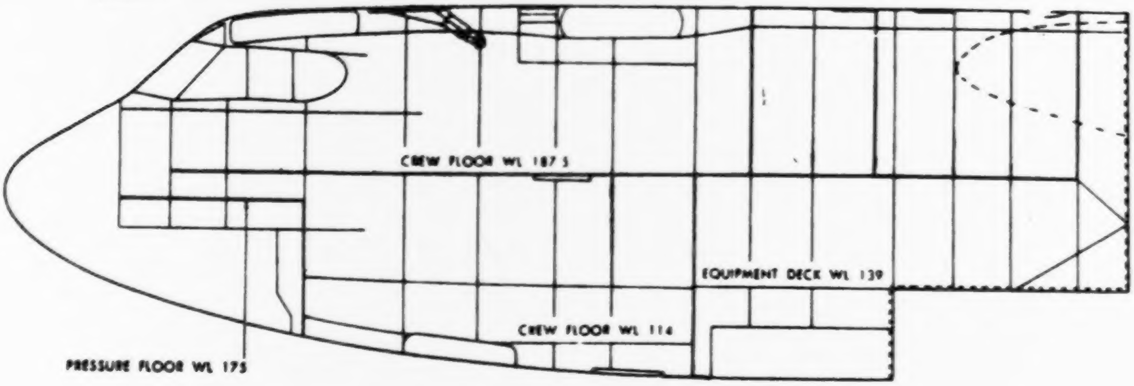
On the response sheet write the correct answers for the questions below.

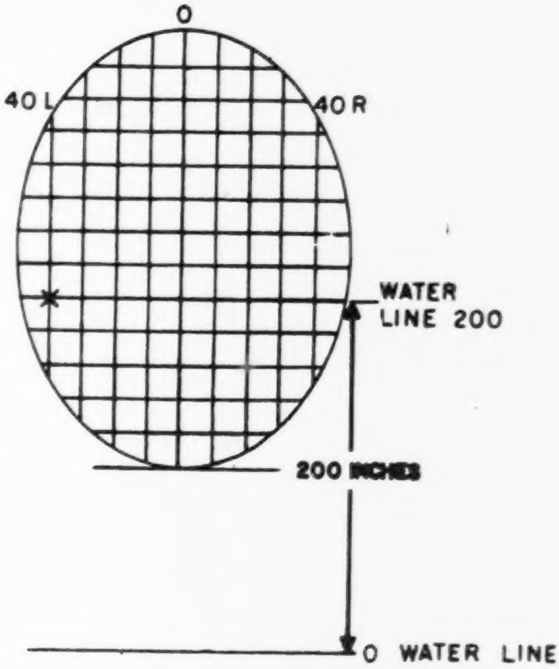
____ 1. Body buttock lines are measured in inches fore and aft of the horizontal centerline of the aircraft.

____ 2. BBL 40L means that this body buttock line is located on the left side of the fuselage and is 40 inches long.

____ 3. BBL 40R means that this body buttock line is located on the right side of the fuselage and is located 40 inches from the vertical centerline.

Frame 4


CREW FLOOR WL 187.5
EQUIPMENT DECK WL 139
CREW FLOOR WL 114
PRESSURE FLOOR WL 175

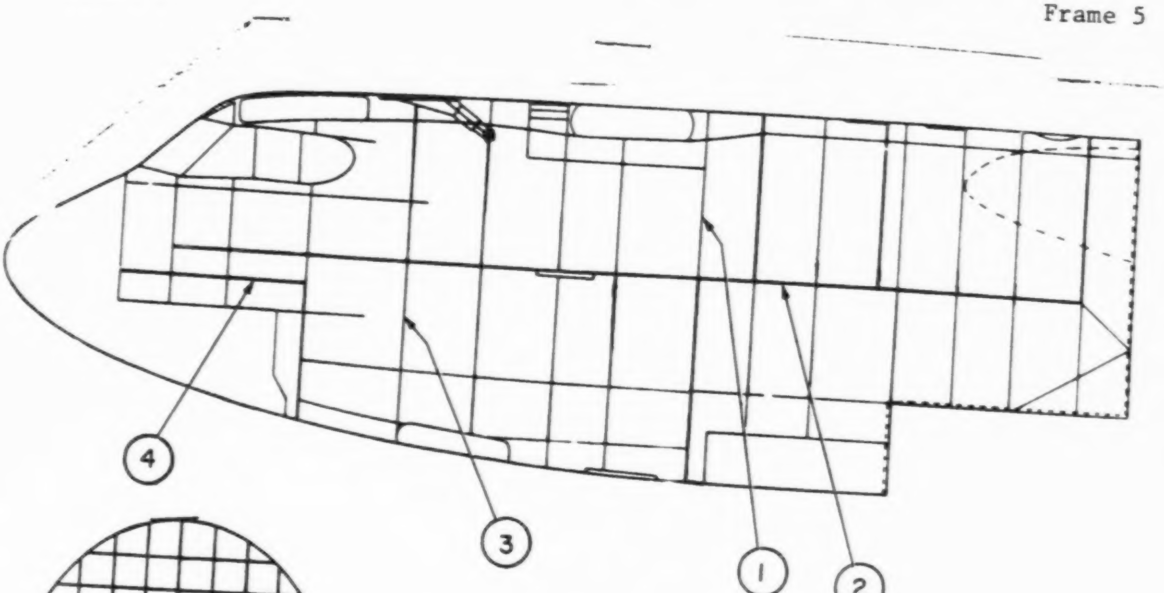

0
40 L
40 R
WATER LINE 200
200 INCHES
0 WATER LINE

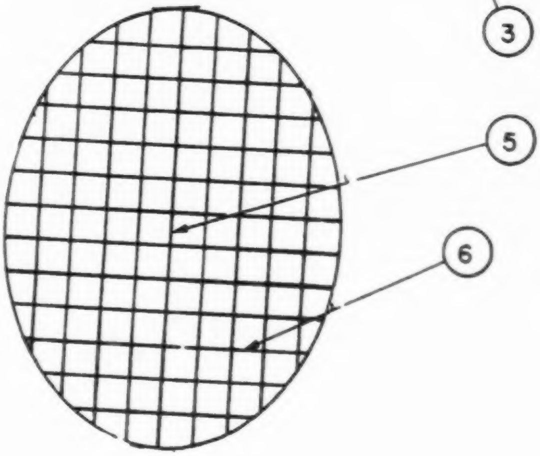
One more reference line is needed to fix the location of a unit. This line starts somewhere below the lowest part of the fuselage. Horizontal parallel lines are drawn upward from this point and numbered. The numbers tell how many inches the lines are above this lowest point. These are called water lines (WLs).

Circle the correct response to the following statement.

Water lines are distances measured in inches from a point

- a. parallel to the vertical centerline.
- b. below the lowest part of the fuselage.
- c. to the right of the vertical centerline.
- d. forward of the nose.





Using the above illustrations, write the designated numbers next to the correct nomenclature listed below. More than one number may be used for each nomenclature.

____ a. Body stations (BS)

____ b. Body buttock lines (BBL).

____ c. Water line (WL).

Note: If you missed any of the above questions, DO NOT GO ANY FURTHER in this text. Review frames 1 through 4 in Section II, until you understand the information and can answer the above questions correctly.

When finishing frames 1 through 5 in Section II go on to Section III, Frame 1.

CORRECT RESPONSES FOR SECTION II

Frame 1

a

Frame 2

1. c
2. c

Frame 3

1. F
2. F
3. T

Frame 4

b

Frame 5

a. 1 & 3

b. 5

c. 2, 4, & 6

SECTION III

MAJOR AIRCRAFT SYSTEMS

Frame 1

In this section we will cover major aircraft systems such as; propulsion, pneumatic system, fuel, pneudraulic (hydraulic), and electrical systems. These systems should be operational if an aircraft is to make a safe flight.

Frame 2

The propulsion (engine) system provides power (thrust) to get the aircraft moving and keep it airborne.

The engine may also drive

- alternator(s)
- generator(s)
- hydraulic pump(s)

and provide pneumatic air power.

The two types of engines most commonly used on today's aircraft are the reciprocating (piston) and the jet engine.

On the response sheet place "T" for true or "F" for false for the following.

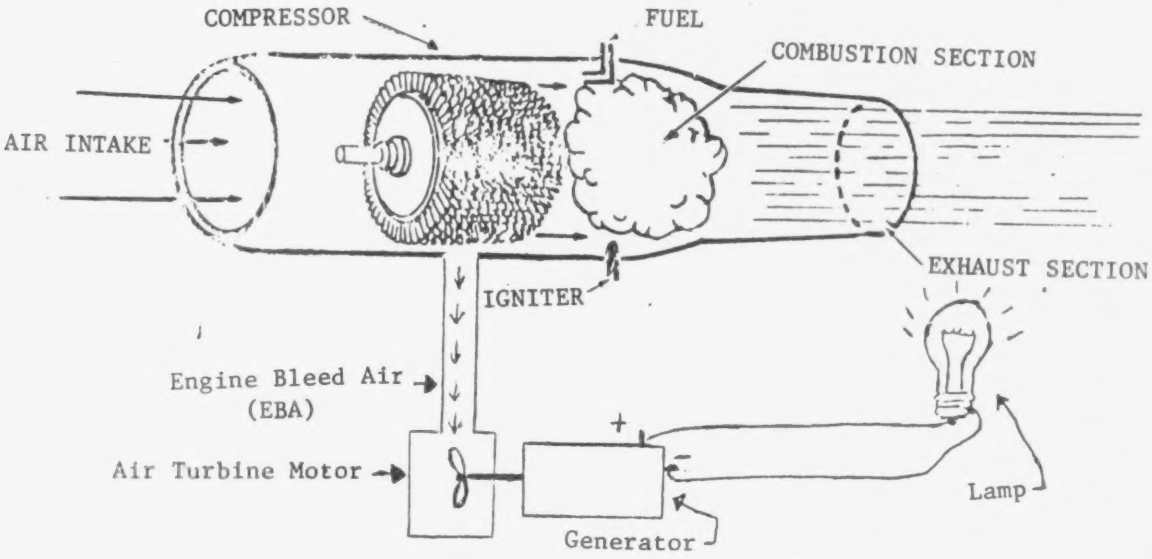
____ 1. The two types of propulsion systems most commonly used on today's aircraft are reciprocating and piston.

____ 2. The propulsion system provides the power to get the aircraft airborne.

____ 3. Alternators and generators may be driven by the engine.

Many military jet aircraft use a pneumatic system (air power) to drive air turbine motors to operate the hydraulic pumps, generators, alternators, and also supply air for the air conditioning system and much more.

This air comes from the compressor section in the jet engine. This compressor has two purposes, compress air for engine combustion and also to supply compressed air, or engine bleed air (EBA) for the pneumatic system. EBA air comes to the pneumatic system under pressure and high temperature.


COMPRESSOR
FUEL
COMBUSTION SECTION
AIR INTAKE
EXHAUST SECTION
IGNITER
Engine Bleed Air (EBA)
+
-
Air Turbine Motor
Lamp
Generator

On the response sheet write the correct answer for the following.

1. The compressor in the jet engine

   a. will provide combustion for the jet engine.

   b. will provide compressed air for the engine combustion and supply EBA for air conditioning.

Frame 4

The fuel system provides storage for large quantities of fuel and also supplies fuel to the engine(s) at the correct pressure and/or quantity. Without fuel or a fuel system, the propulsion systems (engines) are not going to operate. The fuel system may use pneumatic air from a jet engine and/or electric fuel pumps to supply fuel to the engines.

On the response sheet place "T" for true or "F" for false for the following.

____ 1. The fuel systems provide the storage space for fuel and supply fuel to run the engines.

____ 2. A powered aircraft can make a sustained flight without fuel or a fuel system.

____ 3. Only pneumatic power is used to supply fuel to the engine(s).

The aircraft hydraulic (Pneudraulic) system works on the same principles as a farm, auto, or industrial hydraulic system. Just as the modern car has power steering, so have most of today's modern aircraft. The hydraulic system provides the pilot with power steering on the landing gear for maneuvering and braking on the ground. It also provides power for controlling the flight control surfaces (elevators, rudder, ailerons, etc.) while in flight.

There are many other items that depend on the hydraulic system. Some of these systems are the cargo door(s), inflight refueling boom, flight control surface(s), brake(s), etc. You will come in contact with most of these systems on the flight line.

On the response sheet write the correct answer for the following.

1. Moving flight control surface(s) is primarily done with

   a. hydraulic pressure.
   b. electricity.

2. Steering the aircraft and braking the aircraft on the ground is primarily done with

   a. hydraulic pressure.
   b. electricity.

Frame 6

Most of today's modern aircraft electrical power is alternating current (AC) and/or direct current (DC). This power can be supplied by the alternator(s), generator(s), and batteries. These sources of power supply power for the aircraft lighting, electrical, instrument(s), electronic system(s), etc.

On the response sheet write the correct answers for the following.

1. Most of today's aircraft electrical power is supplied by

   a. only DC power source(s).
   b. only AC power source(s).
   c. both AC and DC power sources.

When you have finished correctly SECTION I, II, and III see your instructor and request the test on these three sections. If you have any questions on any part of these three sections see your instructor before you request the test.

CORRECT RESPONSES FOR SECTION III

Frame 1

No response

Frame 2

1. F
2. T
3. T

Frame 3

1. b

Frame 4

1. T
2. F
3. F

Frame 5

1. a
2. a

Frame 6

1. c

Environmental/Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-HO-105
19 June 1984

SAFETY

REFERENCES: AFRs 69-8, 92-1, and 161-35
AFOSH STANDARDS 127-9, 127-12, 127-31, and 127-66
TECH ORDERS 00-110A-1, 1-1A-14, 15X-1-1, and
Applicable Aircraft Manuals

Various hazards are encountered in aircraft maintenance due to the nature of the work. If you cannot identify the hazards, or if you choose to ignore the safety precautions that must be taken, you will be putting your life, and possibly the lives of your co-workers into jeopardy.

WEARING OF JEWELRY - Jewelry usually means, but is not limited to, rings, watches, bracelets, necklaces, earrings, and metal rimmed glasses. The wearing of jewelry while performing maintenance can result in serious injuries such as loss of limb or electrical shock and burns. From this day forward, make it a habit of removing all jewelry before performing any kind of maintenance.

EYE HAZARDS - Eye hazard areas are those operations that could result in impact from flying particles, workers striking stationary objects, and exposure to bright light sources. Examples of eye hazards include: splashes or mists from cleaning solvents, degreasers, corrosive or toxic chemicals, or other liquids; particles of metal from filing or grinding; dust or dirt blown by air hoses; and exposure to a welding arc. You must wear authorized eye protection when working in such areas to avoid serious eye injuries and blindness.

NOISE HAZARDS - The noise created by operating aircraft engines, ground power equipment, and power tools can harm people in many ways. The effects of noise include the loss of sleep, loss of hearing, interference with speech communication, and stress reactions which could have long term health results.

There are three things about hazardous noise that you should know: (1) Repeated unprotected exposure can cause permanent loss of hearing. The loss is very gradual and is not obvious until it is too late. Loss of

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Supersedes ST C3ABR42331-HO-105, 26 October 1983.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Designed for ATC Course Use. Do Not Use on the Job.

hearing cannot be corrected by any known medical or surgical treatment; (2) You can tell if hazardous noise exists by following a general rule: "If you have to shout at 3 feet to be understood, you are in hazardous noise." (3) Permanent hearing loss can be prevented by wearing authorized ear plugs or ear muffs when working in hazardous noise areas. The best protection by far is to wear them both at the same time.

COMPRESSED AIR - Misuse of compressed air, even at very low pressure of 10 to 15 psi, have caused serious injury to workers by blowing foreign particles or liquids into the eyes and ears. In some instances where the velocity of the air was very high it cut through the skin. When working with compressed air, eye protection must be worn. In addition, you should not use it to blow dirt off clothes, never use a pressure greater than 30 psi to clean parts, and never use it in horseplay.

CORROSIVE AND/OR TOXIC CHEMICALS - Direct contact with corrosive chemicals can cause skin irritations (rash) or severe burns. The handling of corrosive chemicals requires the use of protective clothing such as a face mask, a rubber apron and gloves.

Direct contact with, or the inhaling of fumes or vapors created by toxic chemicals may cause anemia, internal organ damage and even death. The handling of toxic agents requires the use of protective clothing and adequate ventilation to remove fumes and vapors.

ELECTRICAL HAZARDS - Aircraft and test equipment work on a variety of voltages and currents. Needless to say, any accidental contact with an energized circuit could really light up your life. Repeated exposure to low level shock may cause bursitis, contraction or dilation in the walls of the blood vessels, and muscle damage. To avoid these hazards you must remove all jewelry before working on or near energized equipment and follow the instructions contained in maintenance manuals, Remember, the proper attitude to have toward electricity is "don´t fear it - understand and respect it."

IMPROPER LIFTING - Hernias, back strains, crushed hands and feet and broken bones may result from an improper lifting technique. An improper lifting technique is one in which a person bends over and uses the back muscles as the lifting force. On the other hand, the proper technique requires that a person lifts from a squatting position with the back straight. In this way the stronger leg muscles provide the lifting force.

MAINTENANCE STANDS - Falling off stands can cause serious injury or death. Some precautions to follow include:

- Inspect the stand for defects before use.
- Keep steps, ladders, and platforms grease and oil free.

- Position the stand close to the work so that the stand does no shift out from under you.
- Install or engage safety locks on lifting devices so that they will not collapse.
- Engage wheel locks before going up so that the stand does not shift out from under you.
- Install guardrails where location and aircraft configuration permit so that you won´t fall off.
- Do not sit or stand on railings to perform work.

AIRCRAFT ENGINES - Besides creating a noise hazard, operating aircraft engines creates some very dangerous (but invisible) situations. One such situation is working around a propeller driven aircraft when the propeller is turning. Since the propeller is nearly invisible when it turns, not paying attention to where you are walking here could really ruin your day. To make them more visible, the tips of the propellers are painted yellow. In addition, a "red" stripe painted on the side of the fuselage shows the propellers "plane of rotation."

A jet engine also has its danger areas. Since these engines have a huge appetite for air, anything or anyone that comes within range of the intake will be sucked up into the engine. As a general rule, you should not come within 25 feet of the front of the intake or within 5 feet of the side or rear of the intake. The safe distance to the rear of the exhaust is even greater, generally, at least 200 feet on foot or in a vehicle. The reason for this is that the temperature of the exhaust air can be around 500 degrees F and its velocity over 100 mph at a distance of 100 feet.

AIRCRAFT RADAR - Radar emits waves of high frequency electromagnetic radiation. These radar waves are like those found in a microwave oven. Exposure to these waves can cause eye cataracts, organ damage and sterility. Since radar units may be located almost anywhere on an aircraft, you must check the applicable aircraft manual for danger areas and minimum safe distances.

NUCLEAR RADIATION - There are a number of ways in which an aircraft could become contaminated. Normally a contaminated aircraft would be decontaminated before you would be allowed to work on it. In the unlikely event that you would be required to work on or near a contaminated aircraft there are a few things that you should know. One of which is the three types of radioactive fallout that can endanger your health.

´ALPHA´ radiation consists of small particles of matter that travel only a few inches from the source. It is a hazard only if it is permitted to get into the body by ingestion (eating or drinking contaminated food), inhalation, or through an unprotected break in the skin. ´BETA´ radiation consists of minute particles of matter and travels about 30 feet from the source. It is normally a hazard only if it is permitted to get into the body, but extreme doses can cause reddening of the skin. ´GAMMA´ radiation is not particulate but is electromagnetic radiation. It is highly penetrative and may travel great distances. Nausea is an early symptom to overexposure. Loss of hair and forms of cancer.

When working in the contaminated area you should: (1) Work only under the supervision of medical personnel and a monitoring team; (2) Wear a ´Dosimeter´ (film badge) which will be used to measure the amount of gamma radiation; and (3) Never smoke or consume food or drink in a contaminated area to avoid ingestion of alpha or beta particles.

After leaving the contaminated area you should: (1) Turn in the dosimeter for evaluation; and (2) Shower and change clothes to get rid of alpha and beta particles.

WORKING WITH OXYGEN - Working on aircraft oxygen systems is a common task for environmental systems specialists. It is a relatively safe task as long as you keep certain facts in mind.

First of all, oxygen itself does not burn but it does support combustion. You must keep sparks, oil and grease away from oxygen system components. Second, don´t smoke after working in an oxygen concentrated area for at least 30 minutes because the oxygen becomes trapped in your clothing. If you were to light a match before your clothes had a chance to air out, your clothes could ignite. third, liquid oxygen (LOX) has a boiling point of -297 degrees F. Direct contact with LOX will result in severe frostbite and burns. Whenever you service with LOX you must wear authorized protective clothing such as a face mask, apron, gloves, and coveralls to protect yourself from leaks or sprays. Finally, high pressure oxygen cylinders must be handled with care. Damaging a cylinder head can cause the cylinder to rocket like a torpedo.

GENERAL MAINTENANCE

Safety Pins - With RED "remove before flight" streamers must be installed as required before performing maintenance areas where safety pins will be installed are: (1) Landing Gear - To prevent the collapsing or accidental raising of the gear; (2) Door Actuators - To prevent fast acting doors from crushing you; and (3) Canopy and Ejection Seat Triggers - The seats are capable of hurling 300 pounds at an initial rate of 60 feet per second.

Buttons, Switches or Levers - When you must work in the cockpit area, respect your lack of knowledge of other systems. Also, be wary of flipping switches, pushing buttons, and moving levers which could cause drop tanks to fall, a drag chute door or speed brake surfaces to open, or a bomb bay door to close on someone and shear him in half. Usually, a sign will be displayed if an out-of-the-ordinary hazardous condition exists in which someone might be injured.

Bleed Air Ducts - When working on or near ducts, always remember, they can be as hot as 1200 degrees F, and have a pressure of 1000 psi.

Working on the Ramp - (or Flight Line) - Wear reflective equipment at night so aircraft and other vehicles can see you. Avoid walking into sharp edges such as wings, doors, antennae, pitot tubes, running aircraft, and vehicles. NEVER sleep on the ramp on the flight line, or anywhere an aircraft or vehicles could run you over at night. You are there to do a job. Get your sleep when you are off duty.

Soldering Burns and Toxic Fumes - Position yourself so as to not directly inhale fumes/vapors. Always use eye protection to protect yourself from splatter.

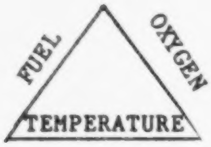
Tripping Hazards - Remove hazardous objects from the work area, floors, walkways and doorways. Rugs and mats should be kept smooth to prevent tripping.

Keep Area Clean - When your work is completed, clean your area up. floors will be kept dry, especially those that are waxed or polished or covered with linoleum.

Cabinet Doors and Drawers - Should not be left open as they usually protrude into the walking area when open. These areas require constant attention as they could cause head and tripping injuries.

Storing Heavy Items - Should be stored on bottom shelves to lessen lifting or dropping hazards.

Fire Triangle



Fires are prevented when anyone of these three parts are eliminated.

Classes of Fire

Class (A) - wood, paper, rags etc. This type of fire will be extinguished by water, CO_2, or dry chemical agents.

Class (B) - Flammable liquids such as gasoline, oil and paint. This type of fire will be extinguished with CO_2, or dry chemical agents.

Class (C) - Electrical Fires. Electrical shorts in wires, motors, and generators produce heat which cause combustible materials in these electrical units to burn. Electrical fires must be extinguished with nonconducting smothering agents such as dry chemicals. Do Not use water on electrical fires as water conducts electricity and you could receive a severe or fatal shock.

Class (D) - Burning metals such as magnesium and titanium. This type of fire will be extinguished with dry chemical agents.

Housekeeping Procedures

Trash will not be stored under stairs, in attics, or under floors in buildings.

Rags will be stored in separate metal containers with tight fitting metal lids and marked "clean" and "dirty."

Oil-Saturated Rags - Will be stored separately from clean and dirty rags in self-closing, metal containers, (example: butt cans), plainly marked with the name of the contents. At the end of the day or shift they must be removed to a safe location outside the shop for scheduled pickup.

Mops and Brooms - Will be hung on a rack with the head at least six (6) inches from the floor.

Steel Wool - will be placed in metal containers with tight fitting lids. Steel wool when rubbed together will cause sparks which could cause a fire.

Trash Receptacles - Only metal receptacles will be used in facilities.

Cigarette Butts and Burned Matches - Smoke ONLY in designated areas. Place cigarette butts and burned matches in special "butt cans" and NOT in trash cans.

Flammable Liquids - Are stored in closed metal containers in designated OUTSIDE areas. Spilled flammable liquids will be cleaned up immediately with noncombustible absorbants such as sand. Never flush into the plumbing system or into floor drains. Do Not use gasoline, naptha, lacquer, paint thinner, and/or alcohol to clean floors. Do Not store flammable liquids in open containers near electrical equipment. The equipment can spark and could start a fire.

PROGRAMMED TEXT
C3ABR42331-PT-106

Technical Training

Aircraft Environmental Systems Mechanic

PHYSICS OF SOLIDS, LIQUIDS, AND GASES

21 October 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: 9.6

OBJECTIVES

1. Specify the result that would occur from a change in pressure and temperature on gases with a minimum of 80% accuracy.

2. Specify the result that would occur from a change in atmospheric conditions on pressure, temperature, and humidity with a minimum of 80% accuracy.

INTRODUCTION

In this programmed text you will become acquainted with the subjects listed in the "Objectives." When you have completed the text, return to the list of objectives and see if you have accomplished them. You will be questioned on the contents of this text and you will be graded according to the extent you have achieved the objectives.

It is essential for anyone becoming an Aircraft Environmental Systems Specialist to understand some of the principles upon which our systems are designed to operate. Knowledge of certain facts will enable you to troubleshoot problems when they arise and help you develop an insight into related problems and lead you to their solutions. Please read the information presented in each small "frame," think about it, and write your answer. Check your answer on the next even numbered page. If you were incorrect, read the frame again to see what caused you to misunderstand. After you are sure of the information, move on to the next frame.

Supersedes 3ABR42331-PT-106, 20 July 1981.
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3370 TCHTG/TTGU-P - 500; DAV - 1

We find that the entire earth is composed of matter and energy. Energy will be discussed in detail in another programmed text so we will discuss only "matter." Matter is ANYTHING that HAS WEIGHT and OCCUPIES SPACE. Matter is found in three physical states, solid, liquid, or gas. You are already familiar with "solids" such as stone, iron, steel, trees, paper, and many others.

From the list below, select those things that are in their SOLID state at room temperature.

a. water

b. copper

c. wood

d. iron

e. oxygen

f. helium

g. books

h. paper

CORRECT RESPONSE TO FRAME 1: b, c, d, g, h

Frame 2

Liquid does not have a definite shape as solids do, but tends to take on the shape of the container it is in. Examples of liquids are water, gasoline, oil, etc.

From this list of materials put an "S" in front of the matter that is in its solid state and an "L" in front of those that are in the liquid state.

a. ________ water

b. ________ wood

c. ________ plastic

d. ________ gasoline

e. ________ kerosene

f. ________ concrete

g. ________ paper

Frame 3

Solids have a definite shape, liquids seek their own level and take on the shape of their container. GASES also assume the shape of the container in which they are confined, but they can be squeezed down to fit into a smaller container or simply allowed to float away. Examples of gaseous substances are steam, oxygen, and hydrogen. Some of these are also invisible.

In the list below, indicate the solids by placing an S in front of the materials that are solids, an L for the liquids, and a G for the items that are normally found in their gaseous state.

a. ____ sand

b. ____ carbon monoxide

c. ____ gasoline

d. ____ milk

e. ____ steam

f. ____ cement (dry)

g. ____ helium

h. ____ water

i. ____ salt

j. ____ diamonds

k. ____ air

l. ____ plywood

m. ____ oxygen

n. ____ oil

CORRECT RESPONSES TO FRAME 2: a. L , b. S , c. S , d. L , e. L ,
f. S , g. S

CORRECT RESPONSES TO FRAME 3: a. S , b. G , c. L , d. L , e. G ,
f. S , g. G , h. L , i. S , j. S ,
k. G , l. S , m. G , n. L

Frame 4

[Certain terms will be used throughout this study of physics and
throughout your tour as a specialist. We will familiarize you with
them as we go. When we speak of matter we generally refer to an
amount of matter in this manner; "the MASS of gold in a bucket is
25 lbs." Naturally we are referring to how much is in the bucket 45
and express that quantity in terms of weight. Then, the mass of
gold in the bucket is 25 lbs. (pounds). Suppose for a moment the
bucket is full of oxygen. Let's say its mass is 5 lbs. If we close 3
the bucket, compress some oxygen and stuff it into the bucket, the
mass will be increased to 10 lbs or maybe more. What has happened
then is this - by squeezing the oxygen we have moved the oxygen's 26
molecules closer together so more of them will fit into] the bucket. 6
We have increased the DENSITY of the oxygen. It can be seen then
that the oxygen will be heavier. Mass and Density are both measurements of quantity but the mass is expressed as weight. Another
example of density is - A forest has 100 trees on one acre of ground.
The forest next to it has 800 trees on one acre of ground. Which
area of forest has the greatest density? The acre with 800 trees
is 8 times as dense as the acre having only 100 trees. They are
packed closer together.

This statement describes DENSITY very well.

"The amount of mass in a given space."

True or False?

Frame 5

The term "FORCE" applies to the total push or pull on matter. Example: If a tank is filled with water and that water weighs 100 lbs. it is pushing down on the bottom of the tank with a FORCE of 100 lbs. The total force on the bottom of the tank is 100 lbs.

Underline the correct answers for each of the statements below.

a. 500 lbs of cement pushes down on the earth with a total force of 500 pounds. (True) (False)

b. "Total push or pull on matter" is the definition of 1. mass 2. density 3. force.

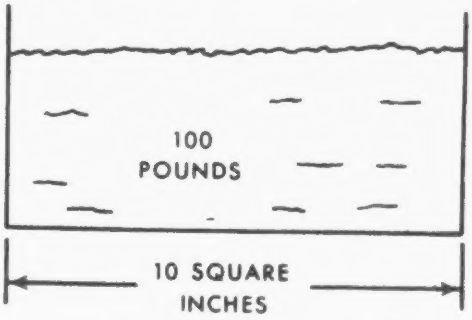
CORRECT RESPONSES TO FRAME 4: True.

CORRECT RESPONSES TO FRAME 5: True, Force.

Frame 6

PRESSURE is a term that you have heard many times. It is used when we wish to express the force applied to a given area and is measured in pounds per square inch (psi). Example: A tank having 100 lbs of water has a total force on its bottom of 100 lbs. But - if the tank's bottom area is 100 inches square, then it will have a PRESSURE of 1 pound per square inch. Since the pressure is one pound per square inch, and the bottom of the tank is 100 inches square, the total force is 100 pounds.

Refer to the illustration below and answer the questions that follow by underlining the correct answer.



a. Total (Force) (Pressure) on the bottom of the tank is 100 lbs.

b. Area of the bottom of the tank is (10 inches) (10 square inches).

c. Pressure in this tank is (100 lbs) (100 psi) (10 lbs) (10 psi) (1000 lbs) (1000 psi).

Frame 7

As a form of review match the terms in Column A with the definitions or statements in Column B by placing the letter of the term next to the definition or statement it matches.

Column A

a. pressure
b. liquid
c. matter
d. solid
e. force
f. gas
g. density

Column B

1. _____ has a definite shape.
2. _____ assumes the shape of its container.
3. _____ total push or pull on matter.
4. _____ force applied to a given area.
5. _____ amount of mass in a given area.
6. _____ can be compressed (squeezed down) to fit a container.
7. _____ has weight and occupies space.

CORRECT RESPONSES TO FRAME 6: a. force b. 10 square inches
c. 10 psi

CORRECT RESPONSES TO FRAME 7: 1. d 2. b 3. e 4. a
5. g 6. f 7. c

Frame 8

You may already be acquainted with the term VELOCITY. It is commonly used when we are talking about the speed and direction of something. Example: If we are talking about how fast a bullet is traveling as it leaves the muzzle of a rifle, we call it muzzle velocity. The term velocity generally includes direction as well as speed.

Units of measurement for velocity are - miles per hour, feet per second, etc., to mention a few of the more common ones. For instance, an automobile's velocity might be 60 miles per hour.

NO RESPONSE REQUIRED

Frame 9

Humidity is a word nearly everyone has heard. We use it when we refer to the moisture in the air. You will hear it often as you continue through this career field.

Write the correct term in the space beside its definition. Terms are in the left column and definitions in the right column.

Humidity
Velocity
Density
Solid
Liquid
Gas
Matter

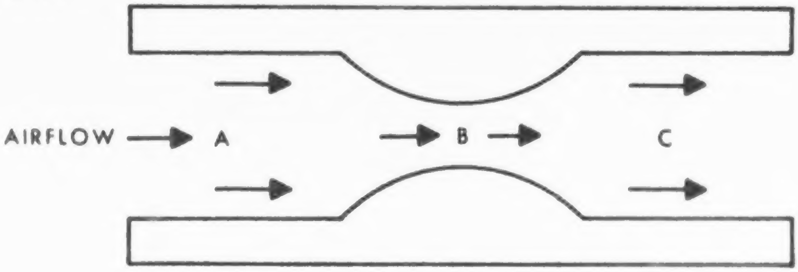
a. ____________ can be compressed.
b. ____________ has a definite shape.
c. ____________ speed and direction of an object.
d. ____________ has weight and occupies space.
e. ____________ moisture in the air.
f. ____________ amount of mass in a given space.
g. ____________ assumes the shape of its container.

CORRECT RESPONSES TO FRAME 9: a. Gas b. Solid c. Velocity d. Matter
e. Humidity f. Density g. Liquid

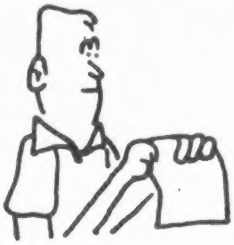
Frame 10

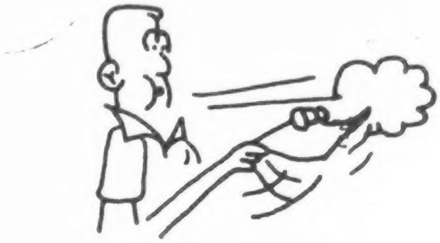
Now that you are familiar with some of the terms used in our career field, we will go on to some of the subjects with which they are associated. So you will see what happens to a gas (air for example) as it passes through pipes in our systems, we have drawn an illustration below that shows the relationship between pressure and velocity. As you study the illustration, keep this fact in mind -

IF THE SAME AMOUNT OF AIR LEAVES A PIPE AS ENTERS IT, PRESSURE WILL BE GREATEST WHERE THE DIAMETER IS LARGEST AND VELOCITY WILL BE GREATEST WHERE THE DIAMETER IS SMALLEST. Look at the illustration as we explain this. Notice the diameter of Point A is the same as the diameter of Point C. If at Point A the Velocity is 100 mph it will also be 100 mph at Point C. BUT it will be much higher (say 500 mph) at Point B. Pressure at Points A and C is 100 psi but at Point B is only 20 psi.



As proof of this "pressure-velocity" relationship hold a piece of paper as shown below and blow a high speed stream of air across the top of the paper.



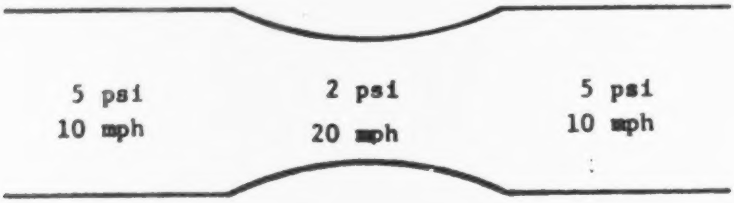


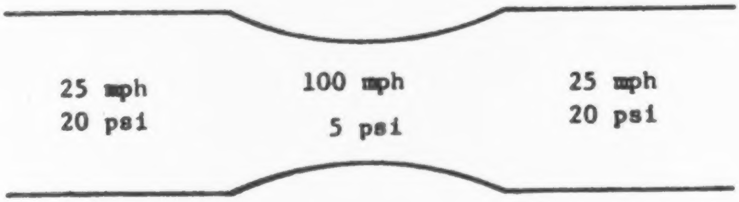
Notice that as the velocity of air increases the paper moves upward toward it! Does this look like the pressure is high where the velocity is high? NO - instead a low pressure area occurs where the velocity is high and because the pressure below the paper is high (and the velocity is zero), the high pressure air below rushes up toward the low pressure area above the paper pushing the paper UP with it.

NO RESPONSE REQUIRED

Frame 11

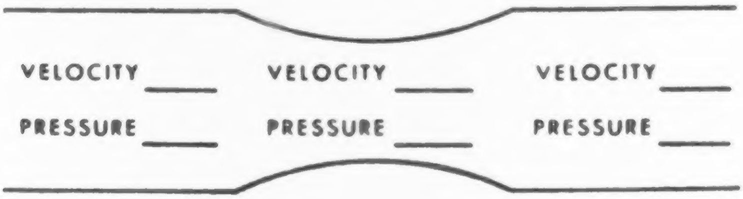
Notice that in the illustrations below we have made a comparison between the pressures and velocities.


5 psi
10 mph
2 psi
20 mph
5 psi
10 mph


25 mph
20 psi
100 mph
5 psi
25 mph
20 psi

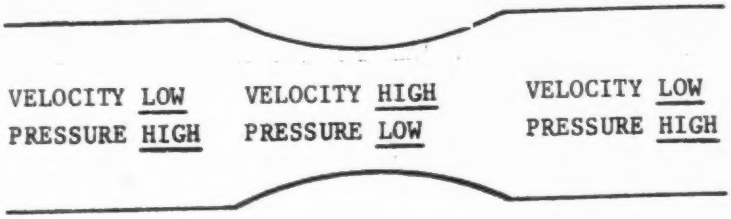
The pressure drops as the velocity of the air increases as it rushes through the narrow part of the pipe.

Think of a squadron of airmen in formation ALL trying to get through a door at the same time. IF as many get through the door as enter it without anyone stopping, someone is going to have to run through that door. The velocity (speed) has increased. The key here is that as many leave as enter. In the illustration below, write the word "High" or "Low" next to the terms Velocity and Pressure according to what it should be at that point.


VELOCITY ____
PRESSURE ____
VELOCITY ____
PRESSURE ____
VELOCITY ____
PRESSURE ____

//////////////////////

CORRECT RESPONSES TO FRAME 11:



Frame 12

Since our systems deal largely with air and its velocity, temperature, density, volume, and pressure, we will look into the relationship between them. Changing one of them has some effect on the others.

If a tank is filled with air (a gas), the cap is placed on, and then the tank is squeezed down to where its volume (volume is how much it can normally hold) becomes much less, what will happen?

Right - the density of the air increases inside, that is, all of the air molecules are squeezed closer together so that as they move around more and more of them strike the walls of the tank. As more of them strike the tank the force inside becomes greater and greater until finally - POW, the tank explodes or pops its seams.

Underline the correct answers to the questions or statements below.

a. If the volume of a tank is decreased, the pressure inside will (increase) (decrease).

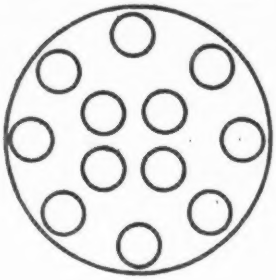
b. The molecules of the air are squeezed together if the volume of the tank is decreased. (True) (False).

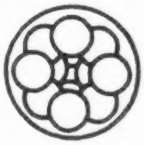
Frame 13

Have you noticed how HOT a compressor becomes as the air is compressed and forced into the storage tank? If the air is compressed, the density increases. All of the molecules of air are squeezed closer together and more of them strike the wall of the tank. They also get hot from rubbing against each other and the inside wall of the tank. These things happen then if a gas (air) is compressed.

The pressure increases.
The temperature increases.
The density increases.

See the difference between these two drawings.


A


B

There are 12 molecules of gas in each of these two containers, but something has happened.

Underline the correct word in the statements below.

a. Tank A has the (greater) (smaller) VOLUME.

b. Tank A has the (greater) (least) DENSITY.

c. Tank B has the (higher) (lower) TEMPERATURE.

d. Tank B has the (greatest) (least) PRESSURE.

e. The walls of tank "B" are being struck by the gas molecules (most often) (least often).

f. Friction between the molecules will be greater in tank (A) (B).

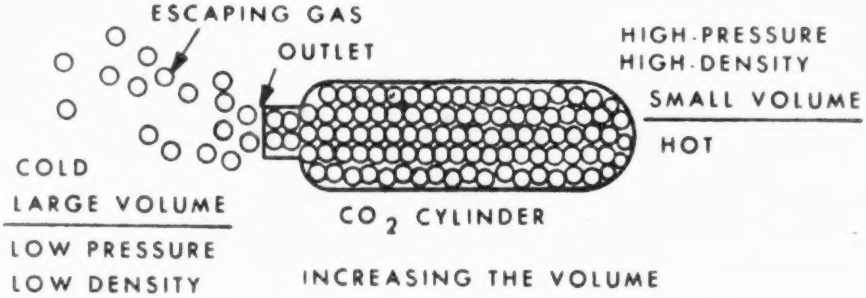
CORRECT RESPONSES TO FRAME 12: a. increase b. true

CORRECT RESPONSES TO FRAME 13: a. greater b. least c. higher
d. greatest e. most often f. B

Frame 14

Looking at it a little differently, we can see that if instead of compressing the gas we EXPAND it, some interesting things happen. Have you ever seen a small CO_2 cartridge fired? Like the ones used in model boats, racers, or airplanes. Remember how the cylinder FROSTED over?

As the volume expanded, the gas came from a small volume in the cylinder to a large volume (the outside air around the cylinder), the molecules moved far apart. The density of the gas has decreased is another way of saying it. The pressure and temperature have dropped at the outlet of the cylinder. Low pressure, cold temperature!


ESCAPING GAS
OUTLET
HIGH-PRESSURE
HIGH-DENSITY
SMALL VOLUME
HOT
COLD
LARGE VOLUME
LOW PRESSURE
LOW DENSITY
CO_2 CYLINDER

INCREASING THE VOLUME

From this example underline the correct words in the statements that follow.

As the volume of a gas increases OUTSIDE of the container:

a. the density (increases) (decreases).

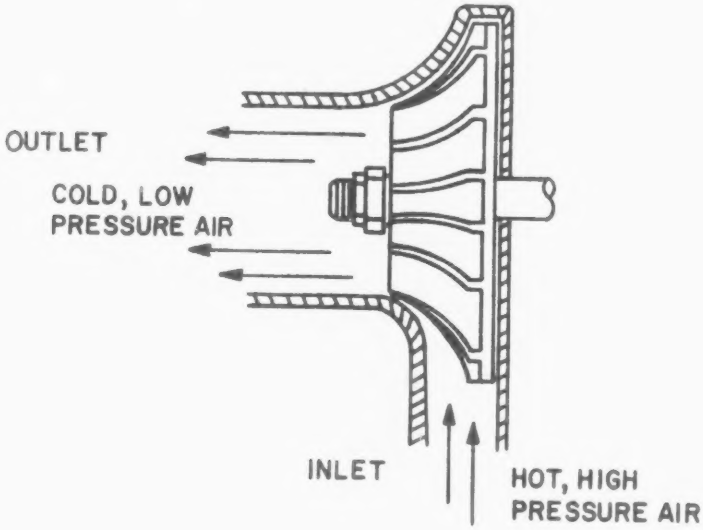
b. the temperature (increases) (decreases).

c. the pressure (increases) (decreases).

d. the gas is being (compressed) (expanded).

Frame 15

Below is an illustration of a "cooling turbine." Notice how it resembles the agitator in a washing machine or a water pump impeller in a car.



High-pressure, high-temperature air is blown from a pipe onto the large end of the turbine where the turbine then EXPANDS the air by rapidly spinning it outward at a tremendous rate.

Remember what you already know about air that has been expanded?

Underline the correct word in each statement below. You may refer to the illustration of the turbine if you wish.

a. The hottest air is at the (inlet) (outlet) end of the turbine.

b. The lowest pressure will be found at the (inlet) (outlet) end of the turbine.

c. The purpose of this turbine is to (compress) (expand) the air.

d. Air is expanded to (cool) (heat) it.

e. Air that is spun out from the outlet end of the turbine is (high-pressure, high-temperature) (low-pressure, low-temperature).

f. This device might properly be called a (cooling turbine) (compressor).

CORRECT RESPONSES TO FRAME 14: a. decreases b. decreases
c. decreases d. expanded

CORRECT RESPONSES TO FRAME 15: a. inlet b. outlet
c. expand d. cool
e. low-pressure, low-temperature
f. cooling turbine

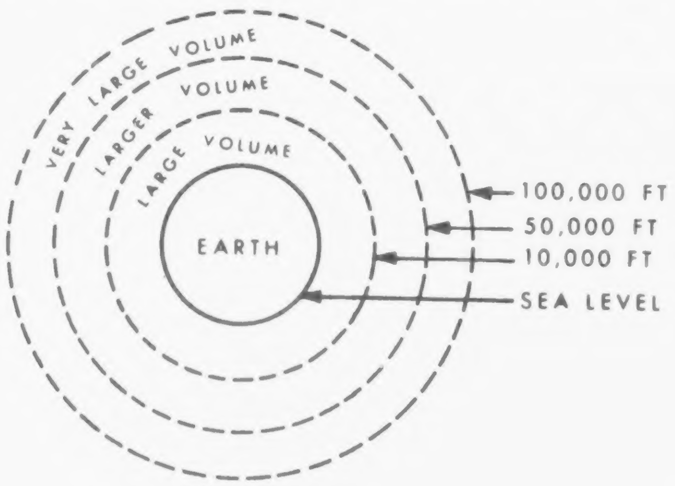
Frame 16

You have seen that changing either temperature, pressure, volume, density, or velocity will have some effect on all the others.

Each of these must be taken into consideration when an air-conditioning system is designed or when something goes wrong and you are required to locate the trouble.

To do this you must extend your thinking to include the effect higher or changing altitudes will have on these principles. This will be easy to understand since you already are familiar with the principles involved.

In the following frames you will see how temperature, density, pressure, and volume vary at different altitudes where aircraft operate.



The Volume of the earth's atmosphere is largest at the highest altitude.

NO RESPONSE REQUIRED

At sea level the air presses on our body with a pressure of 14.69, or 14.7 pounds per square inch. This is normal at sea level but what happens if we go to a higher altitude? Is it the same as at sea level?

The table illustrated below will show you changes that occur at different altitudes. Refer to the table to get the figures you will need to complete the statements that follow. Underline the correct answer wherever it is required.

Table of U. S. Standard Atmosphere

ALTITUDE	PRESSURE		TEMPERATURE		DENSITY RATIO
Feet	Mm of Hg	Lb per sq in	C	F	
0	760.0	14.69	15.0	59.0	1.000
2000	706.6	13.67	11.0	51.9	.9428
4000	656.3	12.69	7.1	44.7	.8881
6000	609.0	11.78	3.1	37.6	.8358
8000	564.4	10.91	– 0.8	30.5	.7859
10000	522.6	10.11	– 4.8	23.3	.7384
12000	483.3	9.35	– 8.8	16.2	.6931
14000	446.4	8.63	–12.7	9.1	.6499
16000	411.8	7.96	–16.7	1.9	.6088
18000	379.4	7.34	–20.7	– 5.3	.5698
20000	349.1	6.75	–24.6	–12.3	.5327
22000	320.8	6.20	–28.6	–19.5	.4947
24000	294.4	5.69	–32.5	–26.6	.4640
26000	269.8	5.22	–36.5	–33.7	.4323
28000	246.9	4.77	–40.5	–40.9	.4023
30000	225.6	4.36	–44.4	–48.0	.3740
32000	205.8	3.98	–48.4	–55.1	.3472
34000	187.4	3.62	–52.4	–62.3	.3218
35332	175.9	3.41	–55.0	–67.0	.3058
36000	170.4	3.30	–55.0	–67.0	.2962
38000	154.9	3.00	–55.0	–67.0	.2692
40000	140.7	2.72	–55.0	–67.0	.2447
42000	127.9	2.47	–55.0	–67.0	.2224
44000	116.3	2.25	–55.0	–67.0	.2021
46000	105.7	2.04	–56.0	–67.0	.1838
48000	96.05	1.86	–55.0	–67.0	.1670
50000	87.30	1.69	–55.0	–67.0	.1518
52000	79.34	1.53	–55.0	–67.0	.1379
54000	72.12	1.39	–55.0	–67.0	.1254
56000	65.55	1.27	–55.0	–67.0	.1140
58000	59.58	1.15	–55.0	–67.0	.1036
60000	54.15	1.05	–55.0	–67.0	.0941

a. At sea level (0-feet) atmospheric pressure is __________ lb per sq in (psi).

b. At 18,000 ft, pressure is ________________ psi.

c. Atmospheric pressure at 18,000 ft is approximately (1/2) (1/4) (two times) as much as it is at sea level.

d. Atmospheric pressure at 60,000 ft is ____________ psi which is about (1/2) (1/15) (two times) (15 times) as much as it is at sea level.

e. The temperature at 50,000 ft is (hotter) (colder) than it is at sea level.

f. The temperature is approximately 0^{o}F at approximately ________________ feet.

g. The temperature stays the same from __________ feet to __________ feet.

h. Density ratio of the air is ____________ at sea level.

i. An air density ratio of .5327 is equal to ____________ feet.

j. At ____________ feet the air density is only 1/4 (approx) or .2447 as much as it is at sea level.

k. The air is (more) (less) dense at 60,000 feet than it is at sea level.

l. Atmospheric pressure is (greater) (less) at 60,000 feet than it is at sea level.

m. Temperature at 60,000 feet is (hotter) (colder) than it is at sea level.

n. VOLUME of the atmosphere at high altitude is (greater) (less) than it is at sea level.

Frame 18

Going back for a moment we can see that a gas is affected by any change in temperature, volume, density and pressure. Now we can compare those very same effects to the effect changing altitudes will have on a gas, such as the atmosphere around us. Did you see that as we increase altitude the VOLUME of the earth's atmosphere increases? Whenever the VOLUME increases, the pressure decreases.

Underline the correct answer to the questions below.

a. At high altitude the VOLUME of the earth's atmosphere (increases) (decreases).

b. The VOLUME of the earth's atmosphere is least at (60,000 feet) (sea level).

CORRECT RESPONSES TO FRAME 17: a. 14.69, b. 7.34, c. 1/2, d. 1.05 and 1/15, e. colder, f. 16,000 (Approx), g. 35, 332 to 60,000, h. 1.000, i. 20,000, j. 40,000, k. less, l. less, m. colder, n. greater.

CORRECT RESPONSES TO FRAME 18: a. increases, b. sea level.

Frame 19

If the volume increases the pressure will be less. The same is true at high altitude. The volume of the atmosphere is much larger, the molecules of air move further apart (become less DENSE) and as a result the PRESSURE decreases.

You may recall that when the pressure drops the TEMPERATURE also decreases. The air molecules have moved further apart and there is less friction between them to heat them.

Let's see if you have these few facts straight. In the chart below underline the word that describes the conditions at the altitude shown by comparing the two altitudes.

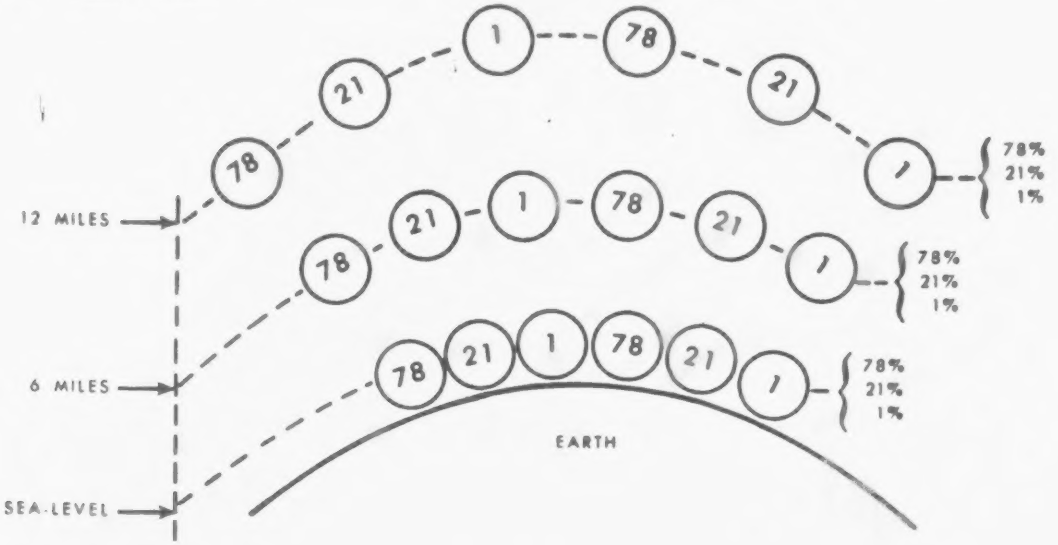
	Sea Level	50,000 Feet
Temperature	(high) (low)	(high) (low)
Pressure	(high) (low)	(high) (low)
Density	(high) (low)	(high) (low)
Volume	(small) (great)	(small) (great)

The earth's atmosphere is actually a sea of gases that surround the earth. This "gas" is made up of several different gases, one of which we depend upon for life support. This gas is oxygen. Nearly everyone knows that without oxygen to breathe, human life would be snuffed out in just a few short minutes.

The sea of gas surrounding us is composed (made up) of nitrogen, oxygen, and other gases in the following percentages . . . .

Nitrogen	78%
Oxygen	21%
Other gases	1%

While oxygen makes up only 21% of the atmosphere there is certainly enough for everyone at sea level. But how about at high altitudes? There's the same 21% at high altitudes with just one very important difference - DENSITY. Remember, the higher you go, the less dense the atmosphere is. (Refer to Frame 19.)



If you drink from a glass of Kool Aid that is made up of 98% water and 2% Kool Aid, you can drink it all down in a few swallows because the molecules in the glass are very dense. Now, spill the same glass of 98% water and 2% Kool Aid into a large shallow pan. Can you get it all up in a few swallows or will you have to move around to get it all up.

You see - the percentage is the same but the density (amount in a given area) has decreased. This is exactly the same for the atmosphere, the same percentage of nitrogen - 78%, oxygen - 21%, and other gases - 1% is at all altitudes but because the molecules are so far apart at high altitude you will not get as many with each breath.

CORRECT RESPONSES TO FRAME 19: high, high, high, small, low, low, low, great

Frame 20 (Cont'd)

Underline the correct answers to the statements below:

a. The percentage of gases in the earth's atmosphere is 78% nitrogen, 21% oxygen, and 1% other gases. (True) (False)

b. There is as much oxygen in a gallon of air scooped up at high altitude as there is in a gallon of air taken at sea level. (True) (False)

c. At 60,000 feet the atmosphere contains (21%) (78%) (91%) oxygen.

d. At 35,000 feet there is (21%) (78%) nitrogen.

Humidity in the atmosphere is something we pay little attention to, but as an Environmental System specialist you'll find humidity can be a problem. Early in this program you learned humidity was the "moisture in the air." We will add at this point that we are concerned only with the humidity below 35,000 feet because above that altitude there isn't enough to worry about. The air can contain a certain amount of water vapor depending on the air temperature.

You have seen water form droplets on the outside of a glass of cold water on a hot day. As soon as the "moisture" in the hot air is cooled by the cold sides of the water glass, it turns from a gas back to a liquid.

What we have said then is that if the atmosphere is "cooled" the moisture (humidity) will turn to a liquid, or in this case, RAIN.

Underline the correct answers to the statements below.

a. Moisture in the air is called (dampness) (humidity).

b. Moisture is only found above 35,000 feet. (true) (false)

c. Droplets will form on the outside of a glass of (hot) (cold) water if the air around it is warm.

d. We can expect to find rain above 35,000 feet. (true) (false)

e. Usually we can expect rain if the temperature drops quickly on a hot day. (true) (false)

CORRECT RESPONSES TO FRAME 20: a. True
b. False (less dense at high altitude)
c. 21%
d. 78%

CORRECT RESPONSES TO FRAME 21: a. humidity b. false c. cold
d. false e. true

Frame 22

Rain falls because the water vapor is cooled until it becomes a liquid. Liquid is heavier than air so the moisture falls in the form of rain. Since the air above 35,000 feet is very cold (see the chart in Frame 17) it cannot hold moisture. In fact the moisture will have cooled and fallen as rain before it ever gets to 35,000 feet.

NO RESPONSE REQUIRED

Frame 23

On some occasions in the future you may be required to use a temperature scale that is different than the Fahrenheit scale you are accustomed to. There is really no difference in scales insofar as physical size is concerned. It is how many lines the scales are divided into that makes the difference.

In figure A we see two thermometers that have been heated the same amount. Notice that the mercury has risen the same amount in each.

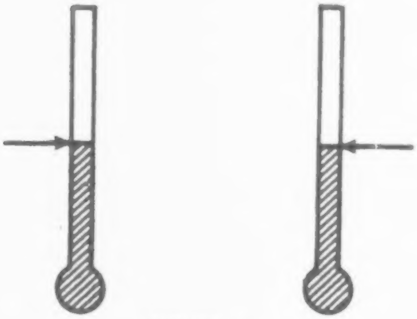
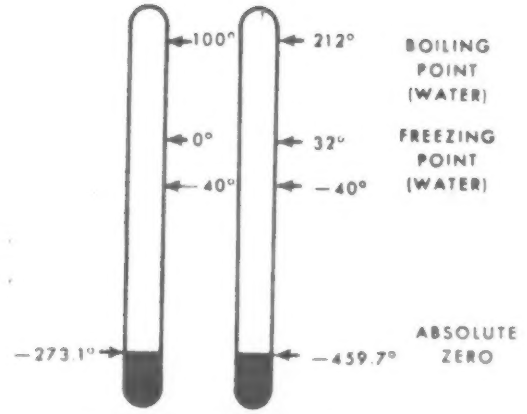


FIGURE A

NO RESPONSE REQUIRED

Frame 24



CELSIUS FAHRENHEIT
SCALES

The two actual scales we will work with are the Fahrenheit scale (you already know this one) and the Celsius scale. The Celsius scale was previously called the Centigrade scale. CENTIGRADE - because it is "graded" in hundredths. The illustration above shows both of the scales. If we compare these two scales to see how much difference there is between the markings on them we will find there is 180° on the Fahrenheit scale for 100° on the Celsius scale. An explanation of this follows.

Look at the Celsius scale. The freezing point of water is 0°, while on the Fahrenheit scale the freezing point of water is 32°. If you look for the boiling point of water (at sea level) you will find it is 100° Celsius and 212° Fahrenheit. Perhaps you noticed there are 100° between freezing and boiling on the Celsius scale, that is 0° to $100^\circ = 100^\circ$ and between 32° and 212° on the Fahrenheit scale there are 180° or 212.

$$\begin{array}{r} 212 \\ \underline{-32} \\ 180 \end{array}$$

Since the actual different is 100° and 180° we can make it easier to remember the difference by breaking it down this way.....

100 - 180
10 - 18
1.0 - 1.8

or for each degree Celsius there are 1.8 degrees Fahrenheit. 1.8 is almost two degrees so it becomes easy to remember that the Fahrenheit scale is nearly twice as large as the Celsius scale. There is one thing that must be remembered -- the Fahrenheit scale STARTS AT 32° (using the freezing point of water as a starting point) so we must allow for this.

You may look at the two scales to answer these questions by underlining the correct answer or filling in the blanks.

a. The scale having the most graduations is the ________________ scale.

b. The lowest mark on the Celsius scale is _________° below zero.

c. Water boils at ________ degrees Celsius and ________ degrees Fahrenheit.

d. There are ________ degrees difference between the freezing points and boiling points of the Fahrenheit scale.

e. The same amount of heat will make the mercury climb higher in one thermometer tube than in the other. (True) (False)

CORRECT RESPONSES TO FRAME 24: a. Fahrenheit b. 273.1° below
c. 100, 212 d. 180 e. false

Frame 25

Zero on the Fahrenheit scale is 32° less than the freezing point of water so we will have to allow for that difference when we convert from one scale to the other. To change a Celsius reading to a Fahrenheit reading it must be remembered the Fahrenheit number will come out larger than the Centigrade number. This is a clue to solving the problem. To make a small number larger you can multiply and add. Let's try one.

Change 25°C to Fahrenheit.

First step - Multiply 25°C by 1.8. (Remember the Fahrenheit scale has 1.8 degrees for every degree Celsius.)

$$\begin{array}{rr} & 25 \\ \times & \underline{1.8} \\ & 200 \\ & \underline{25} \\ = & 45.0 \end{array}$$

Second step - Add

$$\begin{array}{rl} & 45.0 \\ + & \underline{32.0} \text{ (explained above)} \\ = & 77.0^{\circ} \text{ Fahrenheit} \end{array}$$

Therefore, $25^{\circ}\text{C} = 77^{\circ}\text{F}$.

Just two easy steps. Solve the problems below by changing the Celsius Readings to Fahrenheit readings.

Write your answers on this page.

a. 26°C = ____________ $^{\circ}$F

b. 30°C = ____________ $^{\circ}$F

c. 10°C = ____________ $^{\circ}$F

d. 5°C = ____________ $^{\circ}$F

e. 15°C = ____________ $^{\circ}$F

f. 40°C = ____________ $^{\circ}$F

Frame 26

Did you multiply and add in each case? If so, you probably had no trouble arriving at the correct answer each time. It is just as easy to convert Fahrenheit scales to Celsius scales (a large scale to a smaller scale) by SUBTRACTING and DIVIDING. Follow through these easy steps to see how it is done. Change $78.8^{\circ}F$ to Celsius.

First step - Subtract

$$\begin{array}{r} 78.8^{\circ}F \\ -32. \\ \hline 46.8 \end{array}$$

(Don't forget the 32)

Second step - Divide

$$1.8\curvearrowright\overline{)46.8\curvearrowright}$$

$$\begin{array}{r} 26 \\ 18\overline{)468} \\ \underline{36} \\ 108 \\ \underline{108} \\ 0 \end{array}$$

(Remember you must move the decimal)

Answer - $78.8^{\circ}F = 26.0^{\circ}C$

Again, two easy steps, only this time to change a large scale to a small scale we SUBTRACT and then DIVIDE. Now solve a few to see how well you have learned to convert from one scale to the other.

a. $95^{\circ}F$ = ______________ $^{\circ}C$

b. $140^{\circ}F$ = ______________ $^{\circ}C$

c. $70^{\circ}F$ = ______________ $^{\circ}C$

d. $50^{\circ}F$ = ______________ $^{\circ}C$

e. $60^{\circ}F$ = ______________ $^{\circ}C$

f. $100^{\circ}F$ = ______________ $^{\circ}C$

CORRECT RESPONSES TO FRAME 25: a. 78.8°F b. 86.0°F c. 50.0°F
d. 41.0°F e. 59.0°F f. 104.0°F

CORRECT RESPONSES TO FRAME 26: a. 35.0°C b. 60.0°C c. 21.1°C
d. 10.0°C e. 15.6°C f. 37.8°C

Frame 27

If you are honestly doing well at converting from one scale to the other you will enjoy solving the problems we have presented below. If you are a little shaky though, we would rather you go back far enough to reassure yourself and then return to solve these problems.

Using the correct procedure, convert these temperatures. Write your answer in the spaces provided and remember - large to small - subtract then divide, small to large - multiply then add.

a. 50°C = ______________ °F
d. 50°F = ______________ °C.
b. 60°C = ______________ °F
e. 60°F = ______________ °C.
c. 70°C = ______________ °F
f. 115°F = ______________ °C

Frame 28

If you are one of the specialists who may someday have a chance to go to Europe you will find a daily use for temperature conversion. Suppose someone casually says to you, "It must be about 20° Celsius today." Now you're on the spot, how will you answer? There is a simple solution to this dilemma. Try this, to change a small (Centigrade) scale to a large (Fahrenheit) scale, you must MULTIPLY and then ADD. It's difficult to multiply by 1.8 in your head but easy to multiply by 2. Try it --- Someone said it's 20°C today.

Quickly now, 2 x 20 = 40 + 32 = 72°F. Was that hard? 20°C = 72°F. Let's check it. 20°C = °C x 1.8 + 32 = 68°F. Not bad, in fact 72° is close enough to 68° for conversational purposes. Of course, it would be just as easy to tell that Fraulein, "it's a nice cool 10° Celsius, isn't it? How did you do it? You know it was 52°F and that to make a large (°F) scale small (°C) you SUBTRACT and then DIVIDE. Try it. Subtract 32 from 52, you have

$$\begin{array}{r} 52 \\ -32 \\ \hline =20 \end{array}$$

then
then
divide by 2 $\begin{array}{r} 10 \\ 2\overline{)20} \end{array}$

the temperature is 10° Celsius and you look like a genius. How close was your approximation? Check it - (when you divide, watch the decimal point carefully).

$$^\circ C = \frac{^\circ F - 32}{1.8} = \begin{array}{r} 52 \\ -32 \\ \hline 20 \end{array} \qquad 1.8\ \begin{array}{r} 11.1 \\ \hline 20.0 \end{array}$$

The accurate answer is 52°F = 11.1°C. That was close, only 1 degree off.

Convert these in your head.

a. 62°F = __________°C

b. 44°F = __________°C

c. 32°F = __________°C

d. 5°C = __________°F

e. 20°C = __________°F

f. 1°C = __________°F

CORRECT RESPONSES TO FRAME 27: a. 122.0°F b. 140.0°F c. 158.0°F
d. 32.2°C e. 26.7°C f. 46.1°C

CORRECT RESPONSES TO FRAME 28: a. 15°C b. 6°F c. 0°C
d. 42°F e. 72°F f. 34°F

Frame 29

Why did we go to the trouble of showing you a way to do it in your head? It provides you with a means of remembering the PROPER PROCEDURE for temperature scale conversion and as a rough check of your own work to see if you have overlooked any of the steps. Here is an example of how you might use it. Sgt Jones was in a hurry, and using a pencil, he quickly changed 102°F to 51°C.

In your head check his figures to see if he used the proper procedure.

a. The approximate answer should be 35°C. (True) (False)

b. Did he arrive at the correct estimate? (Yes) (No)

c. He should have subtracted 32 and then divided the answer by 2. (True) (False)

d. Using a pencil determine the EXACT answer. The EXACT answer is (35°C) (38.8°C) (51.0°C).

Check your responses for Frame 29 on page 36.

This concludes this portion of physics. If you have any further questions or comments, please bring them to the instructor's attention. He will guide you to the next unit of instruction.

CORRECT RESPONSES TO FRAME 29: a. True b. No c. True d. 38.8°C

PROGRAMMED TEXT
3ABR42331-PT-107

Technical Training

Aircraft Environmental Systems Mechanic

ELECTRON THEORY

2 September 1980

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 8.6

OBJECTIVES

Relate electrical characteristics of materials to the flow of electrical current, and also select the result that would occur from a change in temperature on metals with a minimum of 80% accuracy.

INTRODUCTION

Some of the information that you will study in this PT is background information. Once having mastered the subject matter, you will understand why an electrical current (a flow of electrons) occurs. Understanding how and why current flows will aid you in understanding how electron tubes, solid state devices, and other electronic equipment works.

INSTRUCTIONS

This programmed text presents information in small steps called "frames". Read the material presented, select your response(s) at the end of the frame as required. Do not mark in the text. Enter your response(s) on the response sheet provided. After you have made your selections check your work against the answers on the following page. If the responses are not provided ask your instructor to grade it. If your selections were correct, go on to the next frame and repeat the above process. If you have made an incorrect response, reread the frame until you understand your error and/or see your instructor.

Supersedes 3ABR42331-PT-105, 18 March 1977.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; TTVSA - 1

Our earth and atmosphere is made up of matter and energy. Matter is defined as things that take up space and have weight. Bricks, trees, people, air, paper, milk, wire, steel and water are only a few examples of matter. They all have weight and take up space. Matter can be in three states: solids, liquids, and gases. All matter is made up of small particles called atoms. Atoms which make up one body of material are different from atoms which make up other kinds of materials. But what of those things that do exist and yet do not have weight nor take up space?

For instance: heat, light, sound and electricity. None of these can be weighed. Have you ever seen a tin can full of light? These are forms of energy. Energy is the ability to do work.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on your response sheet.

_____ 1. This P T is an example of matter.

_____ 2. This PT is made up of small particles called atoms.

_____ 3. An atom of silver is identical to an atom of gold.

Next to each item listed in the columns below, write the letter "E" for energy or the letter "M" for matter that correctly describes which it is:

_____ 4. glass

_____ 5. water

_____ 6. electricity

_____ 7. sand

_____ 8. oxygen

_____ 9. light

____ 10. gasoline

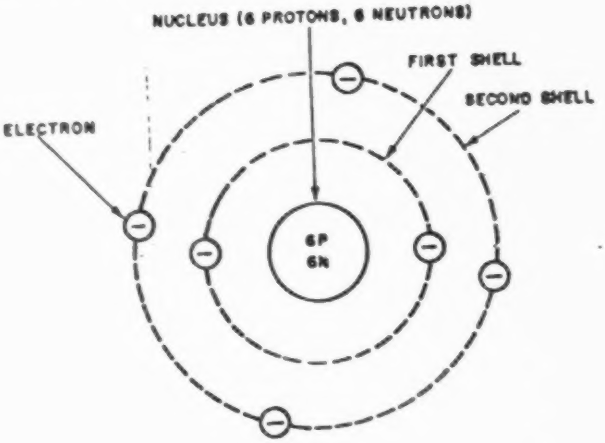
____ 11. heat

____ 12. sound

Answers to Frame 1: 1. T 2. T 3. _ 4. M 5. M 6. E 7. M 8. M 9. E 10. M 11. E 12. E

Frame 2

As we stated in the last frame, the atoms that make up one type of material are very different from the atoms that make up other kinds of materials. These atoms vary in the number of subatomic particles or very small bits that they contain. There are three main subatomic particles which are called PROTONS, NEUTRONS, and ELECTRONS. Of the three, the electron is the most important to you in working with electricity. In the figure shown of the carbon atom, you can see just how the subatomic particles relate to the atom. The protons and neutrons together make up the center or NUCLEUS of the atom, around which the electrons revolve, much like our planet revolves around the sun. The electron is very small and is said to have a very small negative charge of electricity. The proton in the center is said to have a positive charge of electricity. This positive charge is equal in strength but opposite to the charge of the electron.



CARBON ATOM

Mark the following true statements with a "T" on your response sheet.

_____ 1. The electron is considered to have a small negative charge.

_____ 2. The carbon atom pictured above has the same number of electrons as protons.

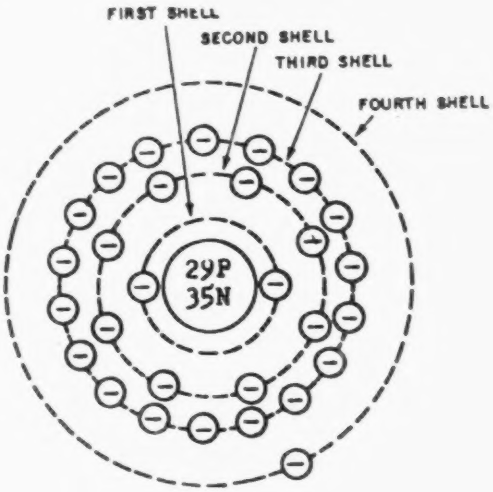
_____ 3. Electrons revolve around the nucleus of an atom.

_____ 4. The proton is considered to have no electrical charge.

Answers to Frame 2: 1. T 2. T 3. T 4. _

Frame 3

In most atoms there is a small part with no charge, called a neutron. This small neutron has a mass just about the same size as a proton but will not have an electrical charge. The protons and neutrons make up a very heavy center or nucleus around which the very light electrons revolve. As the atom becomes more and more complicated, the number of protons and electrons will also increase in number. But, not all of the electrons revolve in the same belt, orbital path or shell as shown in the figure below. The maximum number of electrons that any one belt or shell may have is limited. lectrons in the inside belts or shells, are bound tightly to the nucleus or center of the atom. The electrons in the outer shells are not as tightly bound to the nucleus and when an outside force is applied, the electrons in the outermost shell may be freed from the atom.



COPPER ATOM

Mark the following true statements with a "T" on your response sheet.

_____ 1. Electrons in the outer shells of an atom are easily removed.

_____ 2. The neutron has no electrical charge.

_____ 3. The copper atom shown in this frame has one electron in its outer orbit.

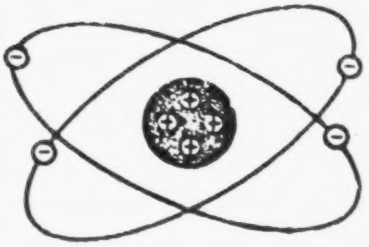
_____ 4. The protons and neutrons together make up an ion.

DO NOT MARK IN THIS TEXT

Answers to Frame 3: 1. T 2. T 3. T 4. _

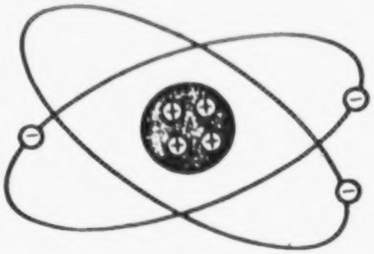
Frame 4

Under normal conditions an atom is electrically neutral, that is, the number of protons is equal to the number of electrons. See figure A. If an atom is not neutral, it is called an ion. For an atom to become an ion it must either lose or gain an electron. If one electron is torn away from the atom as shown in figure B, this will leave the atom with a deficiency of electrons. Thus, this atom has more positive charges than negative charges. This atom is then referred to as a positive ion. In figure C below, this atom has gained an extra electron. This makes it more negatively charged than a neutral atom so it is referred to as a negative ion.



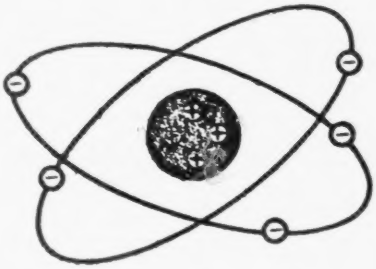
A.

BALANCED ATOM



B.

UNBALANCED ATOM



C.

UNBALANCED ATOM

DO NOT MARK IN THIS TEXT

Mark the correct answer for each of the following questions on the response sheet.

_____ 1. An atom with six electrons and five protons is a

a. negative ion.
b. positive ion.

_____ 2. An atom with six electrons and six protons is a

a. unbalanced atom.
b. balanced atom.

_____ 3. Under certain conditions electrons in the outer orbit can be forced to leave an atom.

a. True
b. False

_____ 4. An atom with eight electrons and nine protons is a

a. negative ion.
b. positive ion.

Answers to Frame 4: 1. a 2. b 3. a 4. b

Frame 5

DO NOT MARK IN THIS TEXT

Match the terms on the right to their descriptions on the left by placing the correct letter in each blank on your response sheet.

NOTE: Each letter may be used more than once.

_____ 1. Negatively charged.

_____ 2. Positively charged.

_____ 3. No electrical charge.

_____ 4. Revolves around the nucleus.

_____ 5. Has mass approximately equal to that of a proton.

_____ 6. Together with the neutrons make up the nucleus of the atom.

a. Neutrons

b. Protons

c. Electrons

Mark the following true statements with a "T" on your response sheet.

_____ 7. A negative ion has more electrons than protons.

_____ 8. Normally an atom has the same number of electrons as protons.

_____ 9. An atom that has gained an electron would be called a positive ion.

Answers to Frame 5: 1. c 2. b 3. a 4. c 5. a 6. b

7. T 8. T 9. _

Frame 6

As was stated in past frames an atom can be made to lose or gain electrons under man-made conditions. The electrons which move from one atom to another are kind of loosely bound to the nucleus. These electrons are referred to as valence electrons. These are the ones that are easiest to take from an atoms outer shell. Maybe now you are wondering where the "lost" electrons go, and where the gained electrons come from. We know that when they go some place or come from some place, there has to be movement involved. This movement of the electrons is defined as current flow, and will be discussed later in this lesson. These electrons that are loosely bound to the nucleus of an atom are referred to as FREE electrons. They are not exactly free, but they will tend to move from one atom to another, exchanging places all the time with other free electrons.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on your response sheet.

_____ 1. Electrons in the outer orbit are the ones most easily removed from an atom.

_____ 2. The electrons that are loosely bound to the nucleus are called free electrons.

Answers to Frame 6: 1. T 2. T

Frame 7

A good conductor is a material that has atoms which have a large number of free electrons. Some good examples of conductors are silver, gold, copper, and aluminum. Silver is a much better conductor than copper, but you will find copper used more often, because it does not cost as much. It is stronger than silver and is very easy to bend and form. Aluminum is light and is used when weight is an important factor. An insulator is a material whose atoms have very few free electrons. No known material is a perfect insulator. Some materials are such poor conductors, that for all practical use, they are rated as insulators. Some examples are glass, dry wood, rubber, mica, and some plastics.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on your response sheet.

_____ 1. A good insulator has many free electrons.

_____ 2. Copper is an example of a good conductor.

_____ 3. Silver has many free electrons.

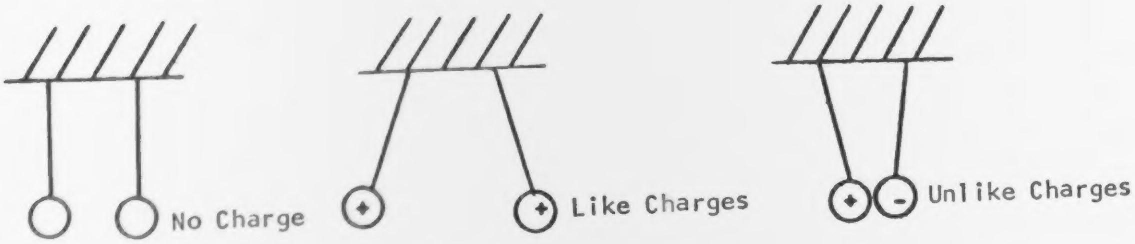
_____ 4. Rubber is an example of a good insulator.

_____ 5. All materials contain the same number of free electrons.

Answers to Frame 7: 1.__ 2. T 3. T 4. T 5. _

Frame 8

Static electricity can be made in a number of ways. You will from time to time feel a shock when you touch the door handle of a car after sliding over its plastic seat covers. The friction made between glass and silk when rubbed with each other will make static electricity the same way as air passing over the skin of an aircraft. Static electricity is generally considered to be electricity at rest. A charged body is one that has more or less than the normal number of electrons. A neutral body is one that has an equal number of electrons and protons in each atom. It can be shown in the figure below that bodies with like charges will push each other apart and those with unlike charges will draw to each other.



DO NOT MARK IN THIS TEXT

Mark the correct answer for each of the following questions on the response sheet.

_____ 1. An atom that has three electrons and two protons would be

a. negatively charged.
b. positively charged.

_____ 2. Two bodies which attract to each other are called

a. positively charged bodies.
b. negatively charged bodies.
c. unlike charged bodies.

_____ 3. Static electricity is sometimes referred to as electricity at rest.

a. True
b. False

Answers to Frame 8: 1. a 2. c 3. a

Frame 9

Static electricity is always present as a hazard around aircraft when bodies of unlike charges are placed close to each other. The charges will try to become equal with each other. When this happens, there will be a small spark jumping from one body to the other body. The greatest hazard here is that this spark can cause fires.

Another problem is that it can cause radio static noise and shock. There are a lot of things used to help reduce the number of hazards from static electricity. Some of these things are grounding wire, static dischargers and bonding wires.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on your response sheet.

_____ 1. Shock is one hazard of static electricity.

_____ 2. Unlike charges will try to equalize when brought together.

_____ 3. Fire can be caused by sparks created by static electricity.

Answers to Frame 9: 1. T 2. T 3. T

Frame 10

A grounding wire can be used to connect a body to the earth to drain its static charges. For example, a grounding wire is used to connect the aircraft and fuel truck to the earth during refueling. A static discharger is a rubber cotton wick which has graphite in it. It is hooked to the trailing edge of the wings, rudders and elevators. It has a sharp point on the end, which gives the excess electrons a path to flow off of the aircraft to the air. The purpose of the static discharger is to eliminate the static charge that is caused by the flow of air over the skin of the aircraft during flight. A bonding wire is used to connect metal parts to each other on the aircraft so that all parts on it will have the same charge. If the aircraft is properly bonded, there will not be any difference in charges between various aircraft parts. As stated earlier, if each body has a different charge these charges will try to equalize and sparking will occur. This could also cause an aircraft fire.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on your response sheet.

_____ 1. The static discharger is used to connect an object to the earth to eliminate static charges.

_____ 2. Bonding wires are used so that all metal parts of the aircraft have an equal amount and the same polarity of charge.

Answers to Frame 10: 1. _ 2. T

Frame 11

Match the terms on the right to their description or examples on the left. Place the correct letter in the blanks provided on the response sheet.

NOTE: The letters may be used more than once.

_____ 1. Contains many free electrons.

_____ 2. Contains few loosely held electrons

_____ 3. Rubber

_____ 4. Copper

_____ 5. Silver

_____ 6. Glass

_____ 7. Aluminum

a. Insulator

b. Good conductor

Mark the following true statements with a "T" on your response sheet.

_____ 8. Two bodies that are positively charged will repel each other.

_____ 9. An atom that has 12 electrons and 11 protons would be an example of a charged body.

_____ 10. The greatest hazard of static electricity around an aircraft is fire.

_____ 11. A ground wire is used to help eliminate static charge.

_____ 12. An electron has a small negative charge.

_____ 13. A positive ion has more protons than electrons.

_____ 14. An atom with 13 electrons and 12 protons is an example of a negative ion.

_____ 15. The subatomic particle that has a negative charge is the neutron.

_____ 16. The proton revolves around the nucleus in paths called shells.

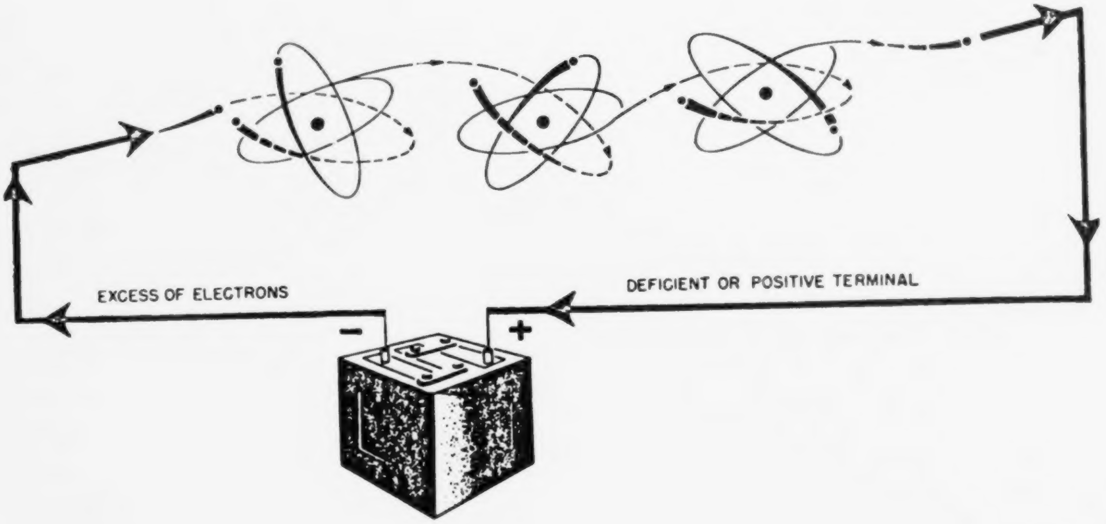
Answers to Frame 11: 1. b 2. a 3. a 4. b 5. b 6. a

7. b 8. T 9. T 10. T 11. T 12. T

13. T 14. T 15. _ 16. _

Frame 12

Earlier you learned that the electrons in the outer shell of an atom may be forced from that atom by some external force. Suppose that a copper wire is connected between two charged bodies as shown below. Remember that copper is a very good conductor and has many free electrons. On one end of the body is a positive charge and at the other end is a negative charge. This means that the positive body has a low sum of electrons and the negative body has an excess sum of electrons. The negative side will repel the free electrons through the copper wire as shown by the arrows. Also, the positive charged mass can be thought of as attracting the electrons. As one electron is forced away from its atom, it makes that atom positively charged. With this atom now at a positive charge, it will try to pull an electron from a close at hand, negative or stable atom, into its own orbit. This is what makes that atom take on a positive charge and this atom will now pull an electron from a different negative atom. The movement of electrons will keep taking place until the two bodies are the same. This flow of electrons is called CURRENT FLOW.



Electron movement through a conductor.

DO NOT MARK IN THIS TEXT

Mark the correct answer for each of the following questions on the response sheet.

_____ 1. The flow of electrons through a conductor is called

a. voltage
b. current

_____ 2. The electron is a small

a. negative charge
b. positive charge

_____ 3. The free electrons move from negative force toward the positive force.

a. True
b. False

Frame 13

In the last frame you learned that electrons will stop flowing between the charged bodies when the bodies become equally charged. In electrical circuits current must flow all the time. Thus, there must be some source that will keep the two points at different pressures so that the electrons will keep on flowing. A source of this type is called a source of electromotive force. Electromotive force (EMF) is a force which will cause electrons to move through a conductor. It is very important that you understand the differences between current (1) and electromotive (EMF) force. EMF was defined as the FORCE THAT CAUSES ELECTRONS TO MOVE THROUGH A CONDUCTOR. Current was defined as the ACTUAL MOVEMENT OF ELECTRONS THROUGH A CONDUCTOR.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on your response sheet.

_____ 1. Electromotive force and current have similar meanings.

_____ 2. In order to have electron flow you must have EMF.

Answers to Frame 12: 1. b 2. a 3. a

Answers to Frame 13: 1. _ 2. T

Frame 14

We now know that in order to have current flow through a conductor we must have a difference in pressure between the two points that the conductor is connected to. This difference in pressure is generally referred to as potential difference or a difference in potential. Two of the most common sources of EMF are batteries and generators. We'll discuss these in a later lesson. The unit of measure for EMF is the volt. From the term volt the word voltage has come into use to mean the same as EMF. The symbol used to represent voltage, potential difference, EMF, or electrical pressure is E.

Mark the following true statements with a "T" on your response sheet.

_____ 1. Voltage and EMF have similar meaning.

_____ 2. An EMF can be used to provide a continuous flow of electrons.

_____ 3. The unit of measure for EMF is volt.

Fill in the blanks with the correct term on your response sheet.

4. The movement of electrons from a negative to a positive potential is called ______________________________.

5. The force that causes electrons to move through a conductor is called ______________________________.

Answers to Frame 14: 1. T 2. T 3. T 4. current

5. voltage or EMF

Frame 15

We know that a good conductor, such as copper, contains many free electrons. When one electron leaves the negative terminal of a source of EMF, it immediately repels a free electron from an atom in the wire. This free electron repels another free electron, etc. A chain reaction takes place throughout the entire conductor. At the same time that one electron leaves the negative terminal, a free electron moves from the conductor into the positive terminal. The net effect of this movement is felt instantaneously between the terminals and through the conductor. The process that goes on inside a source of EMF to keep the negative terminal supplied with an excess of electrons will be explained in a later lesson. The rate at which electrons pass a given point in a conductor is a measure of the amount of current flowing. The unit of measure for current flow is the ampere. The symbol which is usually used to represent electric current is I, which means amount of current.

Mark the correct answer for each of the following questions on the response sheet.

_____ 1. The unit of measure for current flow is

a. EMF.
b. voltage.
c. electron.
d. ampere.

_____ 2. The symbol used to represent electric current is

a. E.
b. I.
c. R.
d. P.

_____ 3. Current is the flow of electrons through a

a. conductor.
b. non-conductor.

_____ 4. The symbol for voltage is

a. I.
b. R.
c. Y.
d. E.

Answers to Frame 15: 1. d 2. b 3. a 4. d

Frame 16

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on your response sheet.

____ 1. The proton has a positive charge on it.

____ 2. The electron orbits around the nucleus in paths, called shells.

____ 3. An atom that has lost an electron would be called a negative ion.

____ 4. Normally an atom is electrically neutral.

____ 5. Silver is an example of a good conductor.

____ 6. A good insulator such as glass has few loosely held electrons.

____ 7. Copper has many free electrons.

____ 8. Two bodies that are positive charges will attract each other.

____ 9. Static electricity can cause fires.

____ 10. An atom with 12 electrons and 12 protons is an example of a charged body.

Match the terms or symbols on the right to their definition or the term they symbolize. Place the correct letter on the blanks provided on the response sheet.

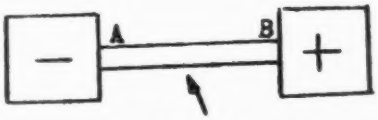
11. Force that causes electrons to move through a conductor.	a. E
	b. I
12. The movement of electrons through a conductor.	c. Voltage
	d. Current
13. Symbol for voltage.	
14. Symbol for current.	

Fill in each blank with the correct term or letter on the response sheet.

15. The unit of measure for EMF is the ____________________.

16. The unit of measure for current is the ____________________.

17. In the figure shown below, the electrons will move from point ____________ to point ____________________.



COPPER WIRE

Answers to Frame 16: 1. T 2. T 3. _ 4. T 5. T 6. T 7. T

8. _ 9. T 10. _ 11. c 12. d 13. a

14. b 15. volt 16. ampere 17. A to B

Frame 17

Since conductors have many free electrons, they will permit a large current to flow in response to little EMF. Since insulators contain very few free electrons, they will permit relatively little current flow in response to a large or great EMF. Actually no material is a perfect insulator. All materials have some free electrons that will flow as current. On the other hand even the best conducting materials available have some opposition to current flow. This opposition to current flow is called resistance. The letter R is used as the symbol for resistance and the unit of measure of resistance is the ohm. A conductor has a resistance of one ohm when an applied voltage of one volt causes a current of one ampere to flow through it.

Fill in each blank with the correct term or symbol on the response sheet.

1. The symbol for current is __________.

2. The symbol for resistance is __________.

3. The unit of measure for voltage is the __________.

4. The opposition to current flow is called __________.

5. The force that causes current flow is called __________.

6. A material that contains very few free electrons is called a/an ______________.

Answers to Frame 17: 1. I 2. R 3. volt 4. resistance 5. voltage or EMF 6. insulator

Frame 18

Conductance is the ability of a material to conduct current; thus it is the opposite of resistance. A material with high conductance would have many free electrons. Copper would have high conductance. A material such as glass, which does not conduct current very well, would have low conductance and high resistance. A material, such as copper, with high conductance would have low resistance, etc. The symbol for conductance is G. The unit of measure of conductance is the mho (ohm spelled backward).

Mark the following true statements with a "T" on your response sheet.

_____ 1. A substance such as rubber has relatively high conductance.

_____ 2. Silver has very high conductance and very low resistance.

Fill in each blank with the correct term or symbol on the response sheet.

3. The ability of a material to conduct current is called ____________________.

4. The symbol for voltage is ____________________.

5. The symbol for conductance is ____________________.

6. The symbol for resistance is ____________________.

7. The unit of measure for resistance is the __________.

8. The unit of measure for conductance is the ____________.

9. The movement of electrons through a conductor is called ____________________.

Answers to Frame 18: 1. _ 2. T 3. conductance 4. E 5. G 6. R

7. ohm 8. mho 9. current

Frame 19

For each of the following descriptions write on the response sheet the term described, the symbol for the term, and the unit of measure for the term. A list of terms, symbols, and units are given for you to use; but the information on any one line is not correctly related.

DO NOT MARK IN THIS TEXT

TERMS	SYMBOLS	UNITS OF MEASURE
Voltage	1	Ohm
Current	R	Mho
Resistance	E	Volt
Conductance	G	Ampere

TERM	SYMBOL OF TERM	UNIT OF MEASURE	
____________	____________	____________	1. Opposition to current flow.
____________	____________	____________	2. Ability of a material to conduct current.
____________	____________	____________	3. Flow of electrons through a conductor.
____________	____________	____________	4. Force that causes the flow of electrons through a conductor.

Answers to Frame 19:

TERMS	SYMBOLS	UNITS OF MEASUREMENT	
resistance	R	Ohm	1.
conductance	G	Mho	2.
current	I	Ampere	3.
voltage	E	Volt	4.

Frame 20

The size and type of material of the wires used in electrical circuits are chosen so as to keep the electrical resistance as low as possible. The electrical resistance of a wire will depend on: (1) its length, (2) its diameter, (3) the type of material, and (4) the temperature. For a given material at a fixed temperature, increasing the length will cause its resistance to increase. Doubling the length will double the resistance. However, the larger the diameter of a conductor, the lower will be its resistance to current flow. This is the teason why large diameter wires are used in high current flow circuits.

Look at the comparison between the figures shown below.

FIG A

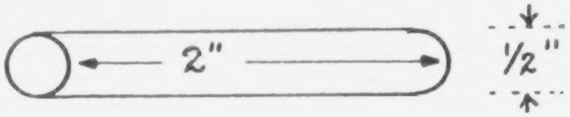


FIG B

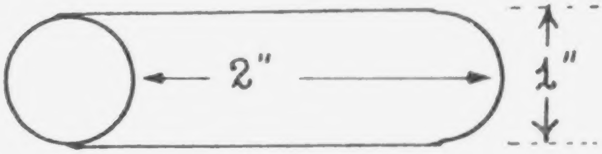


Figure B has twice as large a diameter as figure A. Since it is twice as large in diameter it will have many, many, more free electrons that can be moved and as a result it will have less "Resistance."

Frame 20 (Cont'd)

In this illustration notice the difference in the LENGTH of the two conductors (wires).

FIG A

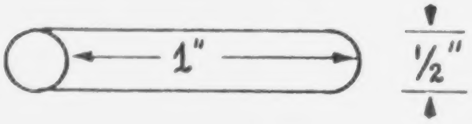
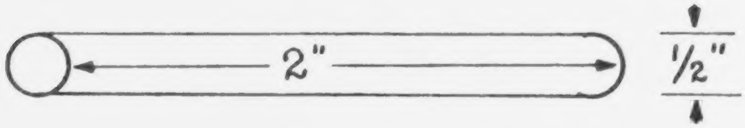


FIG B



The conductor with the greatest length will have the greatest resistance because the electrons have further to travel.

Mark the following true statements with a "T" on your response sheet.

__________ 1. A piece of aluminum wire two feet long will have more resistance than one three feet long.

__________ 2. The larger the diameter of a copper wire, the less resistance it will have.

Frame 21

Different types of materials offer different amounts of resistance. Metals have low resistance whereas glass and rubber have high resistance. In most conductors (copper, aluminum, silver, iron, etc.) the resistance increases with an increase in temperature. These materials are said to have a positive temperature coefficient. The resistance of carbon and liquids decreases with an increase in temperature. These materials are said to have a negative temperature coefficient.

Mark the following true statements with a "T" on your response sheet.

__________ 1. Heating a piece of copper wire will cause its resistance to decrease.

__________ 2. Glass has very high resistance.

__________ 3. All materials increase in resistance when heated.

Answers to Frame 20: 1. _ 2. T

Answers to Frame 21: 1. _ 2. T 3. _

Frame 22

In your own words write the definitions of each of the following terms on the response sheet.

1. Voltage ______________________________
______________________________.

2. Current ______________________________
____

3. Resistance ______________________________
______________________________.

4. Conductance ______________________________
______________________________.

For each of the following terms fill in the correct symbol on the response sheet.

		SYMBOL
5.	Current	______
6.	Voltage	______
7.	Resistance	______
8.	Conductance	______

Mark the following true statements with a "T" on your response sheet.

_________ 9. Heating a piece of aluminum wire will cause its resistance to increase.

_________ 10. The longer a wire is the more resistance it will have.

_________ 11. The larger the diameter of a wire the more resistance it will have.

_________ 12. Copper and aluminum have very low resistance.

_________ 13. The unit of measure for current is the ampere.

_________ 14. The unit of measure for conductance is the ohm.

_________ 15. The unit of measure EMF is the volt.

Answers to Frame 22:

1. the force that causes electrons to move through a conductor.
2. the movement of electrons through a conductor.
3. the opposition to the flow of electrons.
4. the ability of a material to conduct current.

5. I   6. E   7. R   8. G   9. T   10. T   11. _   12. T   13. T

14. _   15. T

Frame 23

The effects of current flow such as heat, chemical, shock, and magnetism depend for their intensity on the amount of current. Heat is produced when current flows through a conductor. You have probably seen applications of the heating effects of current. Also you probably have experienced electrical shock in one form or another. The chemical effect of current can be observed when charging a storage battery such as the one you have in your automobile. The magnetic effect can be both harmful and helpful. In the harmful category it can cause errors in some meters and compasses in aircraft, if not guarded against. In the useful category it makes possible the remote control of circuits. It is also used in voltage generation. You will study magnetism in greater depth in a later lesson.

Mark the correct answer for each of the following questions on the response sheet.

_________ 1. More heat is produced when the current flow through a conductor is

a. increased.
b. decreased.

Answers to Frame 23: 1. a

Frame 24

Match the terms on the right to their description on the left. Place the correct letter on each blank provided on the response sheet.

NOTE: Letters may be used more than once.

____ 1. Positively charged

____ 2. Negatively charged

____ 3. No electrical charge

____ 4. Revolves around the nucleus

a. Neutron

b. Proton

c. Electron

Mark the following true statements with a "T" on your response sheet.

____ 5. A positive ion has more protons than electrons.

____ 6. Normally an atom has the same number of electrons as protons.

____ 7. An atom that has gained an electron would be called a negative ion.

____ 8. A good conductor contains many free electrons.

____ 9. An example of a good insulator is rubber.

____ 10. An example of a good conductor is copper.

____ 11. A good insulator has few free electrons.

____ 12. Like charges attract each other.

____ 13. An atom with nine electrons and seven protons would be positively charged.

____ 14. Electrons flow from a positive potential to a negative potential.

____ 15. EMF and voltage have similar meanings.

____ 16. The flow of electrons through a conductor is called voltage.

____ 17. Heating an aluminum wire will cause its resistance to increase.

____ 18. If all other factors are identical, a copper wire three feet long, will have more resistance than one two feet long.

____ 19. Copper has much lower resistance than rubber.

Fill in the blanks with the correct term on the response sheet.

20. The movement of electrons from a negative to a positive potential is called ________________.

21. The force that causes electrons to move through a conductor is called ________________.

22. The ability of a material to conduct current is called ________________.

23. The opposition to the flow of electrons is called ____________.

For each of the following terms on the response sheet, write the symbol and the unit of measure on the correct line. A list of symbols and units of measure are given below.

SYMBOLS	UNITS OF MEASURE
E	Mho
I	Ohm
R	Volt
G	Ampere

TERMS	SYMBOL	UNIT OF MEASURE
Resistance	24. ____________	25. ____________
Current	26. ____________	27. ____________
Conductance	28. ____________	29. ____________
Voltage	30. ____________	31. ____________

Answers to Frame 24: 1. b 2. c 3. a 4. c 5. T 6. T 7. T 8. T 9. T 10. T 11. T 12. _ 13. _ 14. _ 15. T 16. _ 17. T 18. T 19. T 20. current 21. voltage or EMF 22. conductance 23. resistance 24. R 25. ohm 26. I 27. ampere 28. G 29. mho 30. E 31. volt

PROGRAMMED TEXT
3ABR42331-PT-108

Technical Training

Aircraft Environmental Systems Mechanic

MAGNETISM

2 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 8.8

OBJECTIVES

Identify materials that can be used to make temporary and permanent magnets with 80% accuracy.

Identify the characteristics of magnetic lines of force with 80% accuracy.

INSTRUCTIONS

This programmed text presents information in small steps called "Frames." Carefully study the written material and diagram if one is provided until you are satisfied that you understand its contents. Each frame requires you to respond to the information in some way. For example, you may be required to select the true statements, etc. Specific instructions are provided in each frame. After you have made your response on the response sheet, compare your answers with the answers given at the beginning of the next frame. If you are correct, go on to the next frame. If you are incorrect, study the frame again and correct your mistakes before continuing. Read carefully, select the correct answers and DO NOT HURRY. DO NOT WRITE IN THIS TEXT.

Supersedes 3ABR42331-PT-105A, 25 August 1977.
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3370 TCHTG/TTGU-P - 600; TTVSA - 1

Things such as metal are said to be a magnet if it has the power to draw to it such things as iron, steel, nickel, or cobalt, which are known as magnetic materials. There are two groups of magnets known as, natural magnets and artificial magnets. First we will discuss natural magnets. A natural magnet is found in the earth. Back in the days of the ancient Greeks, they knew that some stones found in the town of Magnesia, in Asia Minor, drew bits of iron to them. These stones were called magnetite. The Orientals learned that if a piece of these rocks were hung in a horizontal plane and allowed to turn, the same end would always point to the north. Then as time went on the Europeans learned of this discovery and used it as a navigator's compass to aid in navigation. Natural magnets have limited practical use because their magnetic force is not always the same and also very weak.

Mark the following true statements with a "T" on the response sheet.

_____1. Natural magnets have many practical uses.

_____2. Natural magnets are very weak magnets.

Answer to Frame 1: _T_ 1. _____ 2.

Frame 2

The first artificial magnets were made by touching the metal to be magnetized with a natural magnet. In later years it was found that an iron bar could be magnetized by aligning the bar with the magnetic field of the earth when it was being forced. In the modern times of today, magnets are made by placing a metal bar in a magnetic field made by an electrical current. We will look at this kind of magnetism later in this text. Man made magnets are made in a wide variety of sizes and shapes, and they are used mostly in electrical equipment. The bar magnet, the horseshoe magnet, and compass needle are the most common types of artificial magnets today. Any substance which is capable of being magnetized or can be drawn to a magnet is called a magnetic substance. Some common magnetic substances are iron, iron alloys such as steel and alnico, cobalt, and nickel. All of the substances that are not attracted by a magnet are usually called nonmagnetic substances. Some common examples of these are wood, glass, copper, and gold. For our purpose in this text, we are chiefly concerned with substances which are noticeably attracted by a magnet and as a result of that, we are not going to get involved in a more detailed classification system.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

_____1. A bar of alnico could be made into a magnet.

_____2. Glass is generally considered to be a nonmagnetic substance.

_____3. Artificial magnets can be made by using an electrical current.

Answers to Frame 2: _T_1. _T_2. _T_3.

Frame 3

Man made magnets may be termed as "permanent" or "temporary" depending on how well they can hold their magnetic strength after the magnetizing force has been removed. Filings of soft iron brought into contact with a magnet will become magnetized and act as small magnets which will in turn draw other soft iron filings to it. When the soft iron filings are removed from the magnet, they will lose their magnetic properties fast. Any magnet which loses its magnetism in a very short time is called a temporary magnet. Substances such as hard steel and alnico will become highly magnetized when brought into contact with a magnet or close to a strong magnetic field. The state of magnetism will be held over a long period of time. Any magnet which can hold its magnetism over a long period of time is called a permanent magnet.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

_____1. Hard steel can be made into a good permanent magnet.

_____2. Temporary magnets retain their magnetism for long periods.

_____3. Soft iron makes good permanent magnets.

Answers to Frame 3: _T_ 1. ____2. ____3.

Frame 4

When a bar magnet labeled A in figure 1 below, is suspended so that it is free to swing, it will swing around and come to rest with one end pointing nearly due north. When this effect was first established, it was decided arbitrarily to call the north-seeking end of the magnet a north pole. The other end was called the south pole. These designations for the ends of a magnet are still used. Frequently, permanent magnets are marked N at the north pole and S at the south pole. If the north pole of a second magnet, labeled B in figure 2, is brought into the vicinity of the north pole of the suspended magnet A, magnet A will be pushed away in the direction of the arrow at that point. From this effect we have the following fundamental law of magnetism: like magnetic poles repel each other. If the south pole of magnet B in figure 3 is placed into the vicinity of the north pole of magnet A, magnet A will be pulled in the direction of the arrow at that point. This effect forms the basis of another fundamental law of magnetism: Unlike magnetic poles attract each other.

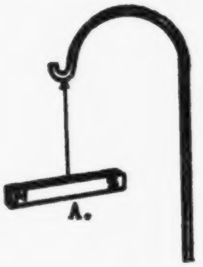


Figure 1.

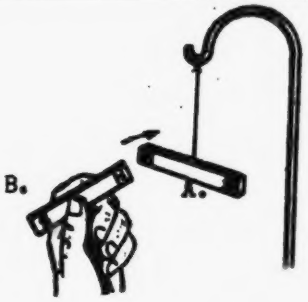


Figure 2.

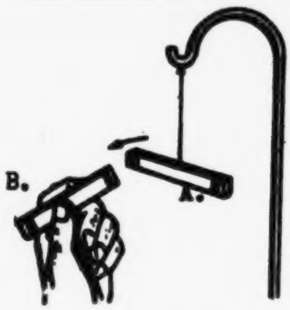


Figure 3.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

____1. Two south magnetic poles will attract each other.

____2. The magnet in figure 1 will have its north pole pointing nearly due north.

____3. Figure 3 shows an example of two magnets repelling each other.

Answers to Frame 4: _____1. _T_2. _____3.

Frame 5

If a bar magnet is dipped into filings, a large number of those filings will cling to the magnet near its ends, but very few will attach themselves to the magnet near its center. See figure 4 below. This shows that the magnetic force is concentrated at the ends or poles of the magnet. The space surrounding a magnet, in which the magnetic force acts, is called a magnetic field. An experiment has been done for you, in figure 5, using a magnet, a piece of paper, and some iron filings used to show the invisible magnetic field pattern around a magnet. One point you should remember is that you are not looking at the magnetic field itself, because the field is invisible; you are looking at the filings which are used to detect the magnetic field. The magnetic field around the magnet causes the iron filings to form themselves into lines that circle the magnet. These lines are called lines of force.

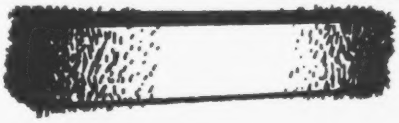


Figure 4.

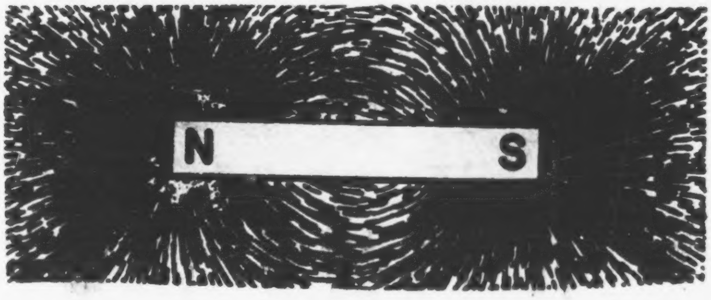


Figure 5.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

_____1. A large number of iron filings will attach themselves to the center of a magnet.

_____2. The area around a magnet where its force can be felt is called its magnetic field.

_____3. From studying figure 1 you might estimate that the magnetic field around the S pole of the magnet is as strong as the field around the N pole.

Answers to Frame 5: ____1. __T__2. __T__3.

Frame 6

In frame 5, we saw the magnetic field pattern around a magnet. A simple and more commonly used method is that of arbitrarily representing the forces in a magnetic field by drawing a few lines called lines of force. See figure 6 below. Note one thing in particular that is revealed by figure 6; the concentration of magnetic field within the metallic bar is very great, while the concentration of the external field decreases very rapidly with distance from the poles. Observe also that arrowheads have been placed on each of the lines of force of the external field. The direction of the arrowheads is away from the north pole and toward the south pole of the magnet. In other words the arrowheads indicate that the lines of force leave the magnet at the north pole and enter the magnet at the south pole. Within the substance of the magnet the direction of the force is assumed to be from the south pole to the north pole so that a continuous loop is formed by each line of force. The direction of magnetic lines of force is defined as the direction in which the north pole of a compass needle will point if placed at any point along a line of force.

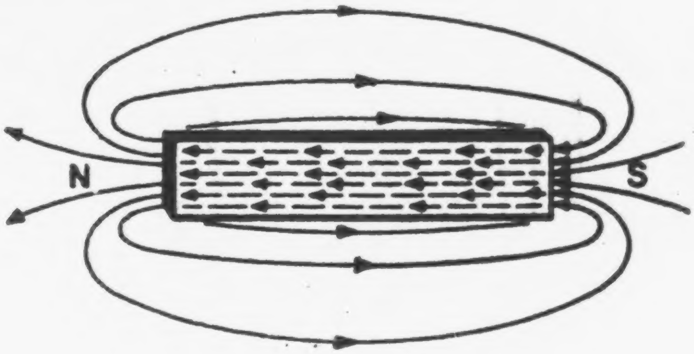


Figure 6.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

____1. The farther you are from a magnet the stronger the magnetic force is.

____2. The lines of force go from north to south inside the magnet.

____3. The magnetic field is concentrated inside the magnet.

____4. Each line of force forms a continuous loop.

Answers to Frame 6: _____1. _____2. __T__3. __T__4.

Frame 7

There are two forces which act upon the lines of force. One is the mutually repellant force that causes them to try to spread out as far away from one another as possible. The other is the force of attraction that they have for the south pole of the magnet; that is as they travel externally from the north pole to the south pole, they try to take the shortest path to the south pole. These two opposing forces account for the pattern of the lines of force that are formed around the magnet. The two opposing forces acting upon the lines of force cause the lines of force to behave as if they were elastic bands stretched out in the field of the magnet. Because of this, if the magnetic force decreases, the lines of force will tend to collapse toward the magnet. If the magnetic field is increased, the lines of force will expand. The greater the strength of the magnet, the farther out into space surrounding the magnet its magnetic force will extend. Also, when the strength of a magnet is increased, the number of lines of force in the magnetic field will also increase. This increased number of lines of force results in the lines being closer together.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

_____1. The stronger the magnetic field the more lines of force that a magnet will have.

_____2. Lines of force act as if they are elastic bands.

_____3. The greater the strength of a magnet, the closer together the lines of force are.

Answers to Frame 7: __T__1. __T__2. __T__3.

Frame 8

There are several basic laws concerning magnetic fields. We have already discussed that (1) lines of force travel from north pole to south pole outside the magnet (south to north inside the magnet); (2) lines of force form continuous loops; and (3) lines of force are elastic and act as if under tension. In figure 6, we observed that the lines of force never crossed one another. Magnetic fields (lines of force) have no known insulator. There is no known substance in the world through which a magnetic field cannot pass.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

_____1. Rubber does not allow the passage of lines of force.

_____2. Lines of force will never cross one another.

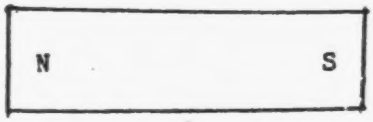
_____3. Lines of force are only continuous on the outside of the magnet.

_____4. Lines of force travel from north to south outside the magnet.

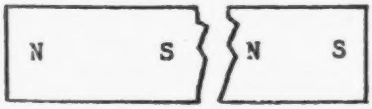
Answers to Frame 8: _____1. __T__2. _____3. __T__4.

Frame 9

When a bar magnet is broken into two separate pieces (refer to figure 7 below) it can be easily shown that each piece will have a north pole and a south pole. The piece which contains the north pole of the original magnet will establish a south pole at the end where the break occurred, and the piece that had the south pole of the original magnet will establish a north pole at the end where the break occurred. Each of the broken pieces of the original magnet can be broken into two more pieces and you will have four magnets. Each time the magnet is broken, a new pole is established at the newly broken end and that pole is of the opposite type to the pole at the other end. If you would continue to break the magnet successively in half until molecular size were obtained, you would find that the tiny molecule is a magnet possessing both a north pole and a south pole, with its own magnetic field.



A
Poles of a bar magnet



B
Poles of a bar magnet
After breakage

Figure 7.

These tiny magnets which are so small that they cannot be seen with a microscope, are thought of as being originally jumbled at random, with no definite order. This is illustrated in part A of figure 8. Considering that these molecules are tiny magnets, you might expect that they would automatically align themselves to form a magnet. Internal stress in the iron or steel can override the small magnetic fields of these magnets and hold them immobile, so that they maintain their haphazard alignment. An artificial magnet can be made by stroking an iron or steel bar with a permanent magnet, as shown in part A of figure 8, provided that the strokes are made in the same direction. If this process is continued, we can align the molecules as shown in part B of figure 8 and we have a magnet. This process is referred to as magnetic induction. Heating or jarring a magnet greatly weakens its magnetic force, since both of these processes make it easier for the molecules to move back to their randomly oriented position.

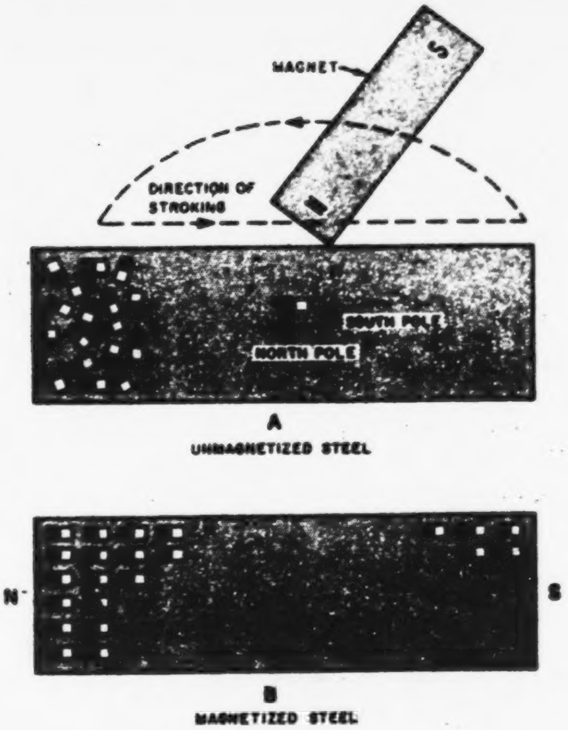

MAGNET
S
DIRECTION OF STROKING
SOUTH POLE
NORTH POLE
A
UNMAGNETIZED STEEL
N
S
B
MAGNETIZED STEEL

Figure 8.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

_____1. A magnet is thought to be composed of many tiny magnets, each with its own magnetic field.

_____2. The molecules of steel will automatically align themselves to form a magnet.

Answers to Frame 9: __T__1. _____2.

Frame 10

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

_____1. Flow from south to north inside the magnet.

_____2. Form continuous loops.

_____3. Will pass through any substance.

_____4. Will cross only at the poles.

_____5. Are concentrated inside the magnet.

_____6. Are elastic and act as if under tension.

Write the letter for one correct answer of the four given on the response sheet.

7. Which of the following substances are used in making temporary magnets?

   a. Hard steel.

   b. Soft iron.

   c. Soft silver.

   d. Glass.

8. Which of the following substances are used in making permanent magnets?

   a. Hard steel.

   b. Soft iron.

   c. Soft silver.

   d. Glass.

Frame 10 (Continued)

DO NOT MARK IN THIS TEXT.

MARK the following true statements with a "T" on the response sheet.

_____9. Unlike magnetic poles repel each other.

____10. Permanent magnets retain their magnetism for long periods of time.

____11. The space surrounding a magnet in which the magnetic lines of force exist is called a magnetic field.

____12. If a magnet is broken in half, it will no longer have any magnetic strength.

____13. All of the following are good magnetic substances: alnico, cobalt, steel, and gold.

Answers to Frame 10: _T_ 1. _T_ 2. _T_ 3. ___ 4. _T_ 5.

_T_ 6. 7. b 8. a ___ 9. _T_ 10.

_T_ 11. ___ 12. ___ 13.

Frame 11

There are a few terms related to magnetism that you should be familiar with. The first term is permeability, which is the measure of the ease with which a given material can conduct magnetic lines of force as compared to air. The permeability of a vacuum is chosen to have a value of 1. The permeability of air has a value of 1.00004; thus, for all practical purposes it can be considered as equal to 1. The permeability of iron is very high, depending upon the grade, generally about 10,000. This means that the magnetic field will find a path through iron that is 10,000 times easier to follow than that through air. The property of permeability is used to direct and concentrate a magnetic field with respect to a given point in space. Figure 9 shows how a magnetic field between the north and south poles of a bar magnet is distorted or directed into a desired path through a soft iron bar. An important application of this property of permeability is the use of magnetic shields, which are made of highly permeable materials, such as soft iron, to protect delicate instruments from damage due to an external magnetic field. If any magnetic substance is placed in a magnetic field it can become mangetized. Many delicate instruments, such as watches and meters, are rendered quite useless if some of their parts become magnetized.

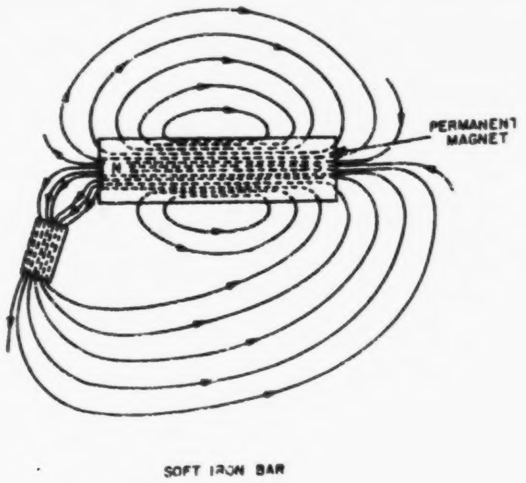


Figure 9.

If, as in figure 10, a soft iron ring is placed around the instrument to be protected, the lines of force from the magnetic source will follow the permeable path through the soft ring, and thus be deflected away from the instrument inside. Your watch is probably another example of shielding. The back of it probably specifies that your watch is antimagnetic or nonmagnetic. This means that the back is made up of a highly permeable material.

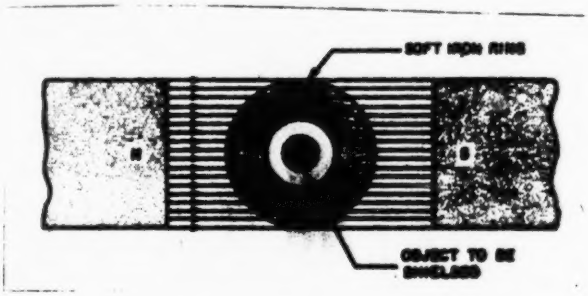


Figure 10.

DO NOT MARK IN THIS TEXT.

Fill in each blank with the correct term on the response sheet.

1. The measure of the ease with which a given material can conduct magnetic lines of force as compared to air is called ________________.

2. A highly permeable substance used to protect a delicate instrument from magnetic lines of force is called a ______________.

Answers to Frame 11: 1. permeability 2. magnetic shield

Frame 12

Another term that you should be familiar with is retentivity, which is the ability of a material to retain its magnetism. Since steel holds its magnetism longer than soft iron, steel has much more retentivity than does soft iron. It means that a material with good retentivity will make a good permanent magnet. Another term that is very similar to retentivity is residual magnetism.

Residual magnetism is the amount of magnetism held by a substance after the magnetizing force has been removed.

Hard steel will have very high residual magnetism so it has high retentivity, whereas, soft iron will have small amounts of residual magnetism and a low retentivity.

DO NOT MARK IN THIS TEXT.

Fill in the blanks with the correct terms on the response sheet.

1. The amount of magnetism retained by a substance after the magnetizing force is removed is called ______________.
2. The ability of a material to retain its magnetism is called __________________.
3. Temporary magnets have (small/large) _________________ amounts of residual magnetism and (high/low) ______________ retentivity.
4. Permanent magnets have (high/low) _________________ retentivity and large amounts of ______________ magnetism.

Answers to Frame 12: 1. residual magnetism 2. retentivity
3. small, low 4. high, residual

Frame 13

The next term you will be concerned with in your study of magnetism is magnetic saturation. A substance is said to be magnetically saturated if increasing the strength of the magnetizing force will not produce any additional magnetic field in the substance. The type of material that is being magnetized will determine the point where the material becomes magnetically saturated. Soft iron has a much lower saturation point than steel or alnico.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

_____1. All magnetic materials have the same saturation point.

_____2. Increasing the strength of the magnetic source above the saturation point will cause a rapid increase in magnetism of the material being magnetized.

_____3. Steel will reach its saturation point before soft iron.

Answers to Frame 13: _____1. _____2. _____3.

Frame 14

DO NOT MARK IN THIS TEXT.

Match the terms on the right to their definition on the left by placing the correct letter in the blank provided on the response sheet.

DEFINITIONS

_____1. Highly permeable material used to protect delicate instruments from damage due to an external magnetic field.

_____2. Measure of ease with which a given material can conduct lines of force.

_____3. Ability of a material to retain its magnetism.

_____4. Point where the magnetic strength of a material will not increase with an increase in the magnetizing force.

_____5. Amount of magnetism retained by a substance after the magnetizing force is removed.

TERMS

a. Magnetic saturation

b. Permeability

c. Magnetic shield

d. Residual magnetism

e. Retentivity

Mark the following true statements with a "T" on the response sheet.

_____6. Soft iron will make a good permanent magnet.

_____7. A permanent magnet will retain its magnetic force for a long period of time.

_____8. Two north poles will attract each other.

_____9. Magnetic field is concentrated inside the magnet.

_____10. The stronger the magnetic field the more lines of force that a magnet will have.

_____11. Lines of force flow urom north to south outside the magnet.

_____12. Hard steel will have higher retentivity than soft iron.

Answers to Frame 14: c 1. b 2. e 3. a 4. d 5.

____6. T 7. ____8. T 9. T 10.

T 11. T 12.

Frame 15

Up to this point we have been concerned with the characteristics of magnets and their magnetic fields. In the next frames you will begin to see the tie-in between magnetism and current flow. You will learn how an electromagnet works and see some examples of how we use magnets.

An electric current has with it certain magnetic effects and these effects obey definite laws. If a compass is placed close to a current carrying conductor, the needle aligns itself at right angles to the wire, thus, it shows that a magnetic field is there, see figure 12 below. The presence of this magnetic force can be shown by sprinkling iron filings on the flat piece of paper this current carrying conductor goes through, see figure 11 below. This shows that a magnetic field exists in circular form around the wire.

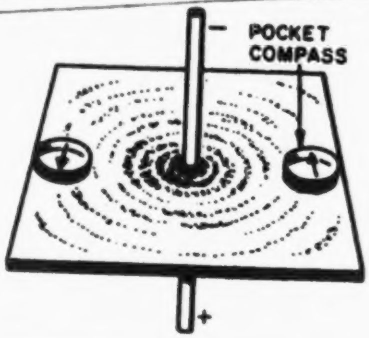


Figure 11.

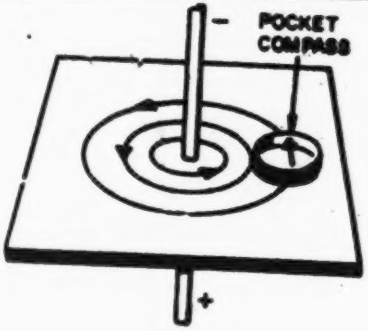


Figure 12.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

____1. Lines of force exist around a conductor that has current flowing in it.

____2. Lines of force form complete circular loops around a current carrying conductor.

____3. A conductor will always have a magnetic field around it.

Answers to Frame 15: _T_ 1. _T_ 2. ____3.

Frame 16

In the last frame we saw that a magnetic field does exist around a current carrying conductor (wire). This magnetic field is very much like the magnetic field around a permanent magnet. We also saw that the lines of force do form circles around a current carrying conductor. Each line of force around the wire acts much like an elastic band. When current in the wire goes up more lines of force are stretched farther out from the wires, but as soon as current flow goes down, some lines spring back toward the wire. Thus lines of force act as if they were under tension. The circular lines around the conductor in figure 13 below show that the lines of force are all along the full length of the wire.

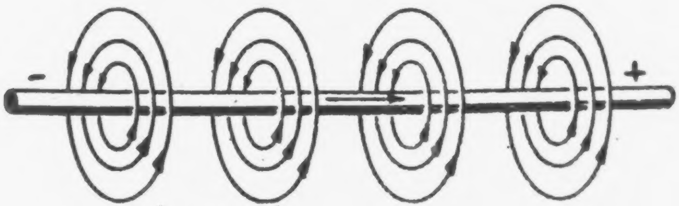


Figure 13.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" concerning lines of force around a current carrying conductor on the response sheet.

_____1. Form complete circles around the conductor.

_____2. Act as if they are under tension.

_____3. Extend farther into space when the current flow through the conductor is increased.

Answers to Frame 16: T 1. T 2. T 3.

Frame 17

Lines of force around a conductor have another distinguishing trait in that they form at right angles to the direction of current flow. The magnetic field around a straight conductor does not have a north or a south pole since the lines of force are in circles. The way in which current is flowing through a conductor determines the direction of the magnetic field around it. A simple rule used to find the direction of the magnetic field when the direction of current flow is known is the left hand rule. It can be stated as follows: Grasp the conductor in the left hand with the thumb pointing in the direction of current flow as shown in figure 14 below. The fingers will point the way the magnetic field goes around the conductor. This rule can also be used to find the direction of current flow through a conductor, if the direction of the magnetic field is known.

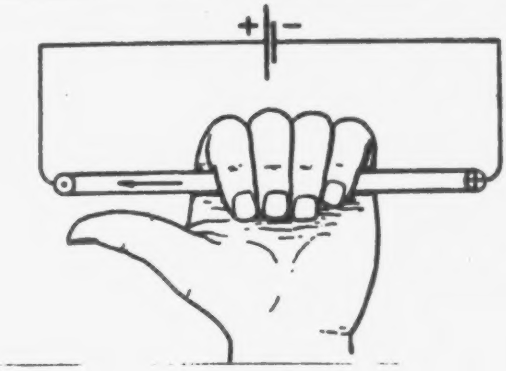


Figure 14.

DO NOT MARK IN THIS TEXT.

Fill in the blanks with the correct word(s) on the response sheet.

1. The direction of the magnetic field is determined by the direction of the _______________ through the conductor.

2. Reversing the current through a conductor will ___________ the direction of the magnetic field surrounding it.

3. Increasing the amount of current flowing through a conductor will _______________ the strength of the magnetic field around it.

Answers to Frame 19: ____1. ____2. _T_3. _T_4. _T_5.

Frame 20

The magnetic fields of two parallel wires with their current flowing in the same direction are shown in figure 17 below.

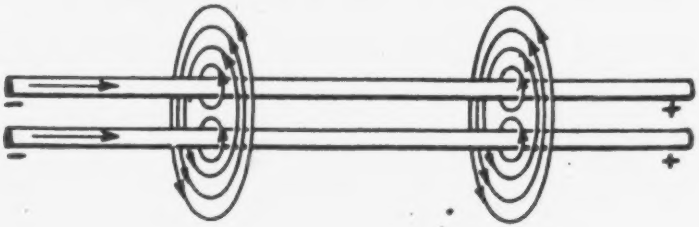


Figure 17.

Notice that in the area between the conductors, the magnetic lines of force oppose each other, while the rest of the lines of force join to form complete magnetic loops which are stronger than the field around either of the separate conductors. The magnetic fields of the two conductors will join only if the currents are flowing in the same direction.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

____1. The magnetic fields of two parallel conductors with current flow in the same direction will be additive.

____2. The magnetic fields of two parallel conductors with current flow in opposite directions will be additive.

____3. The magnetic lines of force between two parallel conductors with current flow in the same direction will combine.

____4. The number of parallel conductors with current flowing in the same direction determine the overall magnetic strength.

Answers to Frame 20: _T_ 1. ___ 2. ___ 3. _T_ 4.

Frame 21

When a wire is wound into a coil of many loops or turns, the magnetic fields around all the loops of wire tend to join to form a large magnetic field. The magnetic field of this coil goes one way inside the coil and the opposite way outside the coil. See figure 18 below. The external lines of force leave the coil at the north pole and go back to the coil at the south pole, just as in a permanent magnet. The same fundamental laws of magnetism apply here also. The polarity of a coil (north or south pole) is determined by the way current flows through the coil windings.

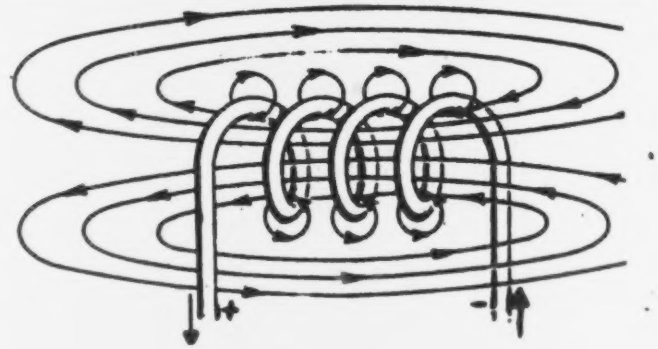


Figure 18.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

___1. The polarity of a coil will remain the same when current direction is reversed through it.

___2. Lines of force travel from north to south inside of a coil.

___3. Adding more turns on a coil will cause the coil's magnetic strength to increase.

Answers to Frame 21: _____1. _____2. __T__3.

Frame 22

Because the direction of the magnetic field (polarity) of a coil depends on the direction of the current flow through the coil, it is possible to figure out which end of the coil is the north pole. A simple rule was made to do this. This rule is referred to as the left hand rule. This rule is as follows: Grasp the coil in your left hand with your fingers pointing in the direction of current flow through the coil windings, as shown in figure 19 below. Your thumb will point toward the north pole of the coil. Care must be taken to be sure the fingers point in the direction of current flow through the coil windings.

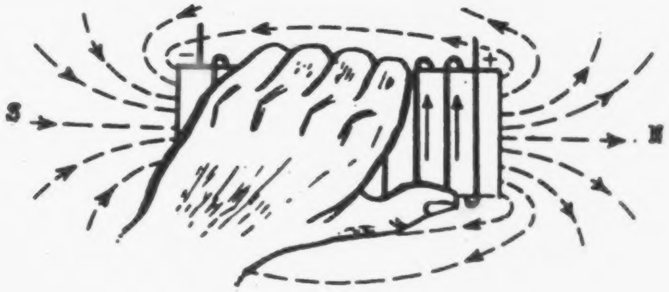


Figure 19.

DO NOT MARK IN THIS TEXT.

Fill in the blanks with the correct words on the response sheet.

1. In using the left hand rule as in figure 19 above, your ______________ point in the direction of current flow, and your ______________ points toward the north pole of the coil.

Answers to Frame 21: fingers, thumb

Frame 23

DO NOT MARK IN THIS TEXT.

Choose one of the four answers given and write its letter on the response sheet.

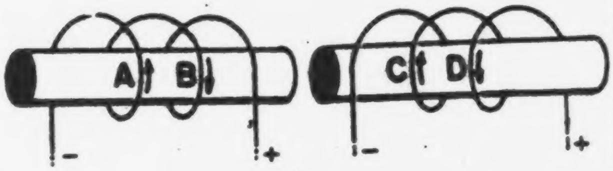
1. The direction of current through these coils is correctly indicated by

   a. arrows A and C.

   b. arrows B and D.

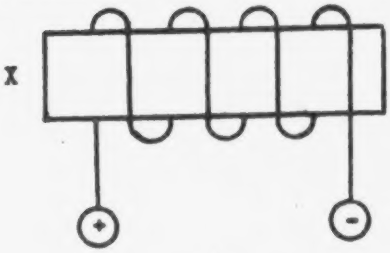
   c. arrows A and D.

   d. arrows B and C.

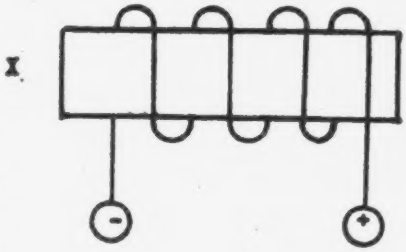


2. Circle the letters of the coils that have a north polarity at point X.

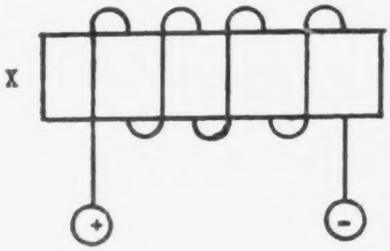
a.



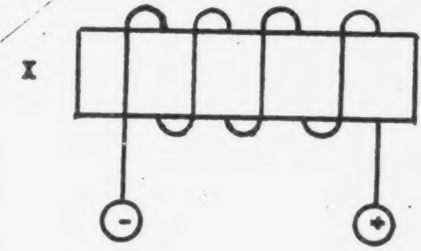
c.



b.



d.



Answers to Frame 23: 1. d 2. b, c

Frame 24

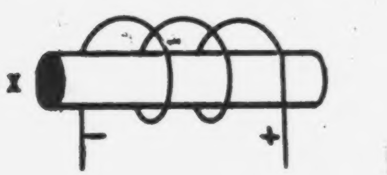
In the last frame you should have seen that if the coil winding direction remains the same and the direction of current flow is reversed, the polarity of the coil will be reversed. The same is true, if the direction of current remains the same and the direction of the coil winding is reversed; the polarity will also reverse. If the direction of winding and current flow are both reversed the polarity will remain the same.

DO NOT MARK IN THIS TEXT.

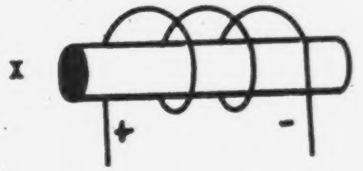
Choose one of the two answers given and write its letter on the response sheet.

1. Which coil has the south pole at point X?

a.



b.



Answer to Frame 24: 1. b

Frame 25

There are several things which will effect the magnetic strength of a coil. One of these is the amount of current flowing through the coil. When current flow increases, the magnetic strength of the coil will also increase. This factor is easy to control because it does not depend on the physical make up of the coil. Another factor which effects the magnetic strength of a coil is the number of turns in the coil. The word "turn" as used here refers to a loop of the conductor in the coil. The more turns on the coil the more magnetic strength the coil will have.

DO NOT MARK IN THIS TEXT.

Fill in the blanks with the correct word(s) on the response sheet.

1. If current flow is decreased through a coil, the magnetic strength of the coil will _______________.
2. If two coils have the same amount of current flowing through them, then the one with five turns will have (more/less) _____________ magnetic strength than the coil with two turns.

Answers to Frame 25: 1. decrease 2. more

Frame 26

The magnetic strength of a coil is also based on how close the turns in the coil are to each other. When the turns are relatively far apart, as shown below in part A of figure 20, many of the lines of force will circle one turn of the coil only. When the turns are close to each other as in B, a great many more lines of force will encircle the whole coil. Thus, coil B will have a stronger magnetic field than will coil A (assuming that both coils have the same amount of current flowing through them). The relationship between magnetic strength and turns in the coil can be summed up in the statement: "The greater the number of turns per inch in a coil, the greater its magnetic strength will be." The magnetic force of a coil, which is based on the turns per inch and the current in the coil, is called "magnetomotive force" and is equal to the current (in amperes) in the coil multiplied by the number of turns per inch.

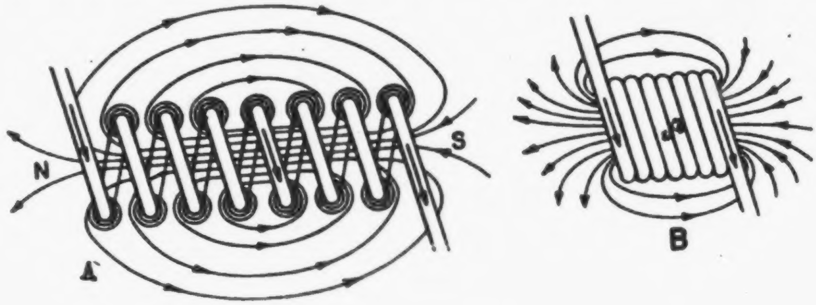


Figure 20.

DO NOT MARK IN THIS TEXT.

Fill in the blanks with the correct word(s) on the response sheet.

1. Magnetomotive force can be increased either by increasing the turns per inch in a coil or by increasing the ___________ through it.

2. The number of turns per inch multiplied by the current (in amperes) is equal to the amount of ________________ force in a coil.

Answers to Frame 26: 1. current 2. magnetomotive

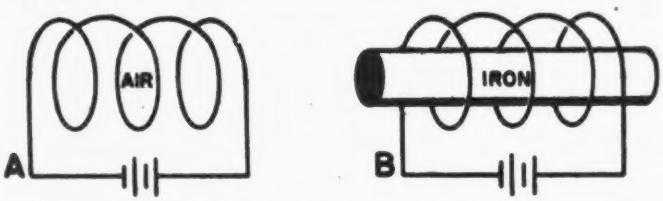
Frame 27

We have just seen that the magnetomotive force in a coil affects the magnetic strength of a coil. The kind of material in the core of a coil also affects the magnetic strength of a coil. If a soft iron bar is inserted into a coil, the magnetic strength of that coil will be increased tremendously. The reason for this is that the iron is much more permeable than air and therefore, more lines of force will flow through the iron. We stated earlier in this programmed text that air has a permeability of about 1.0 whereas soft iron has permeability of about 10,000. This means that the magnetomotive force necessary to produce one line of force inside a coil with an air core, will produce about 10,000 lines of force if a soft iron core is inserted into the coil. This is partly due to the fact that the iron core becomes magnetized and its magnetic field is added to the magnetic field of the coil.

DO NOT MARK IN THIS TEXT.

Choose one of the answers given and write its letter on the response sheet.

1. If the magnetomotive force in each of these coils is the same, the magnetic strength of coil ______________ will be much greater.



2. Three factors mentioned in this programmed text which affect the magnetic strength of a coil are (circle the letter in front of the correct answer).

   a. permeability of the core, flux leakage, and current flow.

   b. permeability of the core, turns per inch, and current flow.

   c. current, voltage, and resistance.

Answers to Frame 27: 1. B 2. b

Frame 28

Reluctance is commonly defined as the opposition offered by a magnetic circuit (for instance a coil) to lines of force. The reluctance of the coil depends on the length of the core, the cross-sectional area of the core and the type of material of the core. The distinguishing traits of the reluctance of a coil are comparable to those of resistance in an electrical circuit. A substance such as hard steel will have more reluctance than will soft iron whereas soft iron has higher permeability than does hard steel. From this we can see that permeability and reluctance are opposites.

DO NOT MARK IN THIS TEXT.

Fill in the blanks with the correct word(s) on the response sheet.

1. The opposition offered by a magnetic circuit to lines of force is called ____________________.

2. Soft iron has (lower/higher) ______________ reluctance than does hard steel.

Answers to Frame 28: 1. reluctance 2. lower

Frame 29

When current flow is increased, the magnetic strength of a coil will increase up to the point of saturation of the core material. At this point very little increase in magnetic strength will occur with a current increase. The amount of current that can flow through the coil is determined by the size of the wire in the coil, the number of turns, and the applied voltage.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

_____1. Magnetic strength will increase very rapidly at saturation.

_____2. As current increases through a coil, the magnetic strength will increase until saturation occurs.

_____3. Decreasing the current flow through a coil will cause the magnetic field to decrease.

Answers to Frame 29: ____1. __T__2. __T__3.

Frame 30

A current carrying coil which has a core of magnetic material is commonly called an electromagnet. Many electromagnets use iron cores due to the fact that iron is easily magnetized. Some electromagnets, such as the one in figure 21 below, are so large and powerful that they can lift tons of scrap metal at one time. Other electromagnets used in some electrical and electronic circuits are very small. Magnets commonly used can be classified as either permanent magnets or electromagnets (temporary).

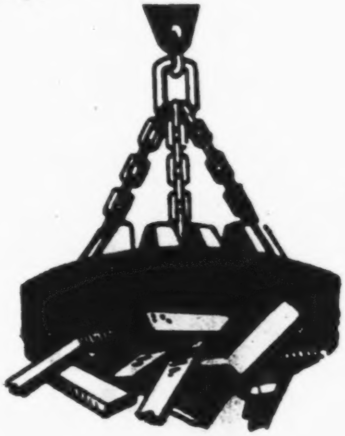


Figure 21.

DO NOT MARK IN THIS TEXT.

Fill in the blanks with the correct word on the response sheet.

1. A coil which is wound on a core of magnetic material is called an ________________________.

2. Horseshoe magnets, bar magnets, compass needles, which work without electrical power, are all ________________ magnets, while magnets which get their power from the current in a coil are ______________.

3. Regardless of the sources of the fields around magnets, they all ________________ the fundamental laws of magnetism.

Answers to Frame 30: 1. electromagnet 2. permanent electromagnets

3. obey

Frame 31

As stated earlier, electromagnets are used in many electrical devices such as circuit breakers, relays and micropositioners. You will study all of them in greater detail in a later lesson. However, let us take a closer look at the use of electromagnets in a meter used to measure current flow.

If an electromagnet is mounted on a pivot between the poles of a permanent magnet as in figure 22, as current flows through the coil, the poles of the electromagnet will be repelled by the poles of the permanent magnet. The more current that is flowing through the coil, the more the electromagnet will turn. If a needle is attached to the coil as in figure 23 below, and a calibrated scale is added, we can measure the amount of current flowing in the coil.

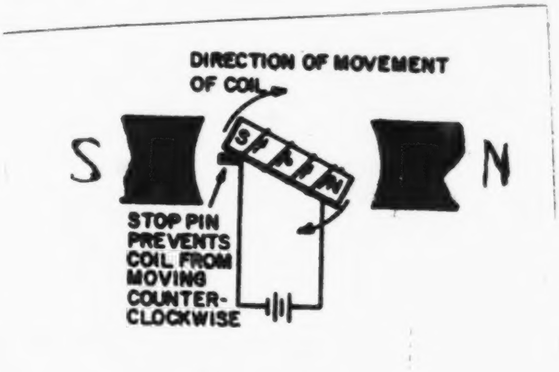

S
DIRECTION OF MOVEMENT OF COIL
S
N
N
STOP PIN PREVENTS COIL FROM MOVING COUNTER-CLOCKWISE

Figure 22.

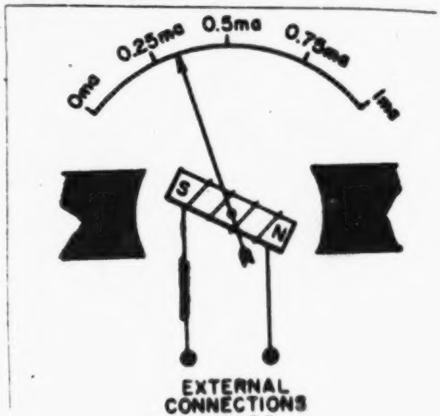

0ma
0.25ma
0.5ma
0.75ma
1ma
S
N
EXTERNAL CONNECTIONS

Figure 23.

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

_____1. In figure 22 the electromagnet is attracting the permanent magnet.

_____2. The coil in the meter movement in figure 22 can turn in either direction.

_____3. Electromagnets have many uses in electrical devices.

Answers to Frame 31: _____1. _____2. __T__3.

Frame 32

DO NOT MARK IN THIS TEXT.

Select those factor(s) that cause the magnetic strength of an electromagnet to increase by placing a checkmark in the blank provided on the response sheet.

_____1. Decrease the number of turns of the coil.

_____2. Decrease the distance between the turns of the coil.

_____3. Decrease the current flow through the coil.

_____4. Replace an air core with an iron core in the coil.

_____5. Increase the distance between the turns of the coil.

_____6. Increase the current flow through the coil.

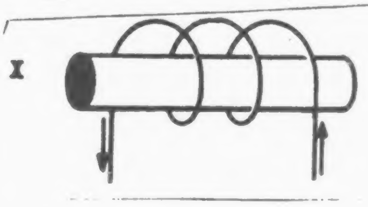
_____7. Remove the iron core from the coil.

_____8. Increase the number of turns of the coil.

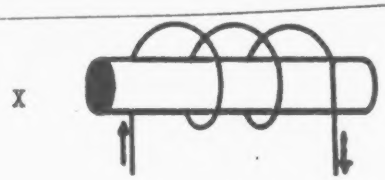
Choose one of the answers given and write its letter on the response sheet.

9. Which coil has the north pole at point X?

a.



b.



10. Which of the following would make the best magnetic shield?

a. Hard steel.

b. Soft iron.

c. Soft silver.

d. Alnico.

Answers to Frame 32: _____1. __T__2. _____3. __T__4. _____5.
__T__6. _____7. __T__8. 9. b 10. b

Frame 33

DO NOT MARK IN THIS TEXT.

Mark the following true statements with a "T" on the response sheet.

_____1. Soft iron is used to make temporary magnets.

_____2. Permanent magnets retain their magnetism for long periods of time.

_____3. Like magnetic poles will attract each other.

_____4. Alnico is used in making permanent magnets.

_____5. The space surrounding a magnet in which the magnetic force acts is called a magnetic field.

Select the statement(s) that correctly describe the magnetic lines of force by placing a checkmark in the blank provided on the response sheet.

_____6. Are elastic and act as if under tension.

_____7. Will cross at the poles.

_____8. Will not pass through glass.

_____9. Form continuous loops.

____10. Flow from south to north outside the magnet.

Fill in the blanks with the correct term on the response sheet. A list of terms is given below for you to use.

11. The measure of the ease with which a given material can conduct magnetic lines of force as compared to air is called _______________.

12. The amount of magnetism retained by a substance after the magnetizing force is removed is called __________.

13. A highly permeable substance used to protect a delicate instrument from magnetic lines of force is called a _______________.

14. The ability of a material to retain its magnetism is called _____________.

Reluctance

Retentivity

Residual Magnetism

Permeability

Magnetic Shield

Magnetic Saturation

15. Point where the magnetic strength of a material will not increase with an increase in the magnetizing force is called ______________.

16. The opposition offered by a magnetic circuit to lines of force is called ___________.

Answers to Frame 33:

_T_ 1.

_T_ 2.

____ 3.

_T_ 4.

_T_ 5.

_T_ 6.

____ 7.

____ 8.

_T_ 9.

____ 10.

11. Permeability

12. Residual Magnetism

13. Magnetic Shield

14. Retentivity

15. Magnetic Saturation

16. Reluctance

PROGRAMMED TEXT

3ABR42331-PT-109

Technical Training

Aircraft Environmental Systems Mechanic

DC GENERATION AND BASIC CIRCUIT SYMBOLS AND TERMS

9 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 8.6

OBJECTIVES

1. Relate basic facts to the generation of an electromotive force.
2. Specify the basic symbols used in electrical circuits.

Each of the above objectives will be accomplished with a minimum of 80% accuracy.

INSTRUCTIONS

Read each frame carefully beginning with the first frame. Answer the questions at the end of each frame in accordance with the instructions provided in the frame. Check your responses with the correct answers which are located on the top of the next frame. If you made an error, determine the cause and correct it before going on to the next frame. When you complete this lesson, contact your instructor for further instructions. Write all your answers on the response sheet. DO NOT MARK IN THIS TEXT!

Supersedes 3ABR42331-PT-105B, 19 August 1977.
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DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; TTVSA - 1

Frame 1

The most complex electrical circuit can be reduced to a very basic circuit. Therefore, there is a great need for you to know all of the basic symbols in order to read these circuits. A basic circuit has five main parts each of which we will talk about as we move on into this lesson. These five main parts are the power source which supplied EMF to the load unit, conductor, protective device, and the controlling device.

Mark the following true statements with a "T" on the response sheet.

____ 1. Basic circuits are not meaningful to you.

____ 2. A basic circuit has five components.

____ 3. One of the components of a basic circuit is a power source which supplies EMF.

____ 4. One of the components of a basic circuit is a multimeter.

Answers to Frame 1: ____1. _T_2. _T_3. ____4.

Frame 2

First, let us talk about some common sources of EMF. In the lesson on electron theory we defined EMF as the force that will cause free electrons to move in a conductor (wire) from a negative potential to a positive potential. There are a lot of ways to generate voltage, but we are only going to talk about three of the more common types with which you will be dealing. They are chemical, mechanical, and heat.

Mark the following true statements with a "T" on the response sheet.

____ 1. EMF is the force that causes electron flow.

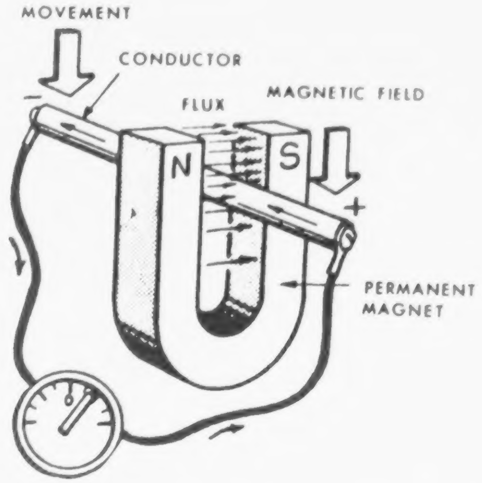
____ 2. There are only three methods of voltage generation.

____ 3. A source of EMF is needed for current flow.

Answers to Frame 2: __T__ 1. _____ 2. __T__ 3.

Frame 3

First of all we will look at the mechanical method that is used to make an EMF. In this method a device is used that will change mechanical energy to electrical energy. The generator that we will find on our cars and on an aircraft and those that supply power to our homes are examples of this device. As the generator is turned, the conductors on the inside are moved through (cut) magnetic lines of force, this will induce a voltage in the conductor.



The above sketch shows this type of voltage generation in one of the simpler ways. You can see that the magnetic field is made by a "U" shaped permanent magnet. The conductor is hooked to a meter that acts as a load. Mechanical energy of some sort is used to move the conductor through the magnetic field. This will induce a voltage in the conductor. The voltage will flow through the wires and meter connected to the conductor and the meter will show the amount of induced voltage.

Mark the following true statements with a "T" on the response sheet.

____ 1. A generator changes electrical energy to mechanical energy.

____ 2. Voltage can be produced by moving a conductor so that it cuts magnetic lines of force.

____ 3. The energy used to operate the electrical units on the aircraft is energy that has been changed from mechanical energy supplied by the engines.

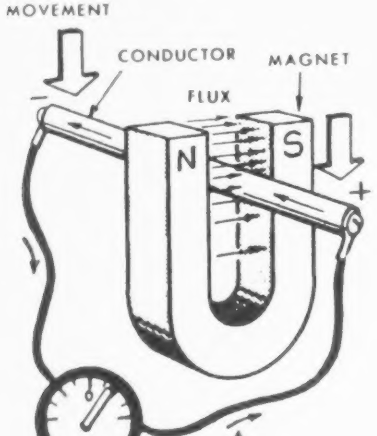
____ 4. The generator is one of the LEAST used devices for generating or producing voltage.

Answers to Frame 3: ____1. __T__2. __T__3. ____4.

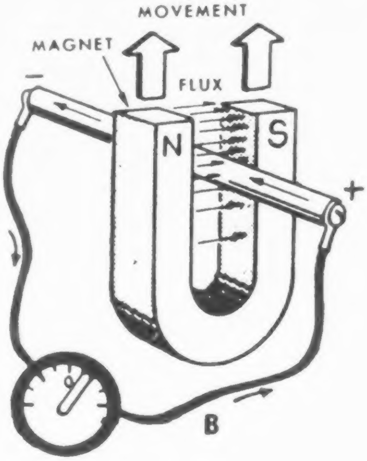
Frame 4

In sketch "A" you can see that the "U" shaped magnet does not move but that the conductor does move down. In sketch "B" note that the magnet moves up and the conductor does not move. From these sketches it is easy to see that the outcome is the same; a voltage was induced in the conductor. A voltage will be made any time a conductor moves through magnetic lines of force.

The conductor must move across (not parallel to) the lines of force in order for it to "cut" these lines of force. A relationship will exist between the motion of the conductor and the angle at which it cuts the lines of force. This relationship is called relative angular motion. It can be said that when there is relative angular motion between a conductor and a magnetic field a voltage will be induced in that conductor. This is called electromagnetic induction. Electromagnetic induction is the principle of operation of all generators.



A



B

Mark the following true statements with a "T" on the response sheet.

____ 1. Voltage is induced in a conductor when both the conductor and the magnetic field are moved in the same direction at the same rate of speed.

____ 2. If there is relative angular motion between a conductor and a magnetic field, electromagnetic induction will take place.

____ 3. The motion required for voltage generation may be provided by moving either the conductor or the field.

Answers to Frame 4: _____ 1. __T__ 2. __T__ 3.

Frame 5

You have now learned how to produce voltage by the mechanical method; now let us see how voltage can go up and down. This is done by increasing the speed of the relative angular motion between the conductor and the magnetic field. This means that the conductor will cut more lines of force in a given time which will cause the induced voltage to go up. Making the strength of the field go up means there will be more lines of force for a given area. If the magnetic field was to go up, and speed stay the same, the conductor would cut more lines of force in a given time, and the induced voltage would go up. Another way of making the voltage produced go up, is to add more conductors. When a conductor is wound to form a coil (as thread on a spool), there will be more) conductors to cut the lines of force. Since the turns of the wire are in the same direction, the voltages are additive, and the total induced voltage will go up.

Mark the following true statements with a "T" on the response sheet.

_____ 1. Increasing the speed of the relative angular motion between a conductor and a magnetic field decreases induced voltage.

_____ 2. Decreasing the strength of the magnetic field through which a conductor cuts the lines of force decreases voltage induced in the conductor.

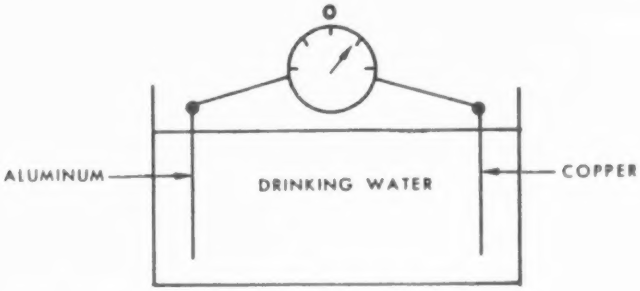
_____ 3. Increasing the number of turns in a conductor cutting magnetic lines of force decreases induced voltage in the conductor.

_____ 4. Speed, strength of the magnetic field, and the number of turns of the conductor are three factors which affect the amount of voltage induced in the conductor by electromagnetic induction.

Answers to Frame 5: _____1. __T__2. _____3. __T__4.

Frame 6

The next way of producing a voltage is by the chemical method. The battery in a car, or the cell in a flashlight are examples of voltage generation by the chemical method. If any two metals, which are not the same, are put in a solution that will conduct electricity, a voltage is produced. The metals are referred to as plates. The solution in which the plates are put is called electrolyte. If a plate of copper, and a plate of aluminum are put in a container of drinking water, a voltage is produced. In the sketch below, note the deflection of the needle on the meter which is hooked up to the copper and aluminum plates in the drinking water.



Mark the following true statements with a "T" on the response sheet.

____ 1. Two like metals immersed in an electrolyte produce a voltage.

____ 2. The voltage produced by immersing copper and aluminum in drinking water is produced by the chemical method.

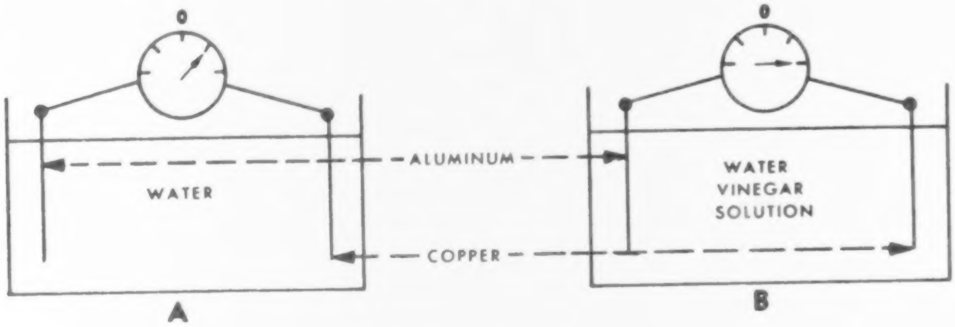
____ 3. Copper and iron plates immersed in drinking water produce a voltage.

____ 4. The materials immersed in electrolyte to produce voltage are called plates.

Answers to Frame 6: ____ 1. _T_ 2. _T_ 3. _T_ 4.

Frame 7

Since you know how voltage can be produced by the chemical method, let us find out how the voltage can be raised or lowered. One way to do this is to use a different electrolyte. A and B in the sketch below are identical except for the electrolyte. The one on the left uses drinking water as the electrolyte, and the other one uses a solution of vinegar and water as the electrolyte. Note that the vinegar and water solution will make a greater needle deflection on the meter. This will tell you that a higher voltage is produced.



Mark the following true statements with a "T" on the response sheet.

____ 1. If the same two unlike metals are immersed in a different kind of electrolyte, the same amount of voltage is produced.

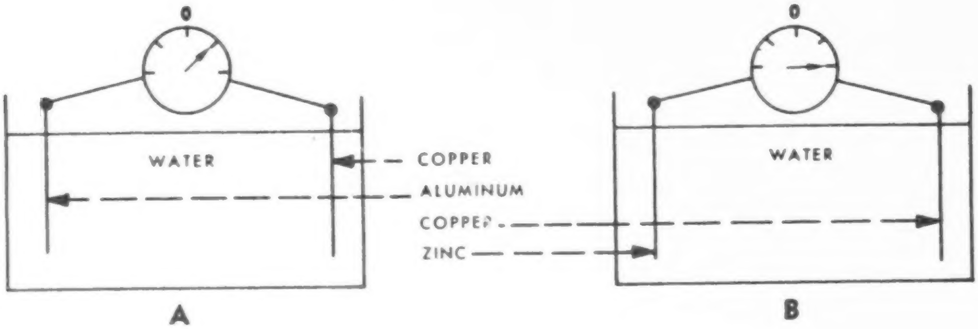
____ 2. In the above illustration, voltage is being produced by the chemical method.

____ 3. The meters in the illustration indicate that a higher voltage is produced with the electrolyte of vinegar and water solution than with drinking water.

Answers to Frame 7: ____ 1. __T__ 2. __T__ 3.

Frame 8

We have found that the same combination of metals when put in different types of electrolyte will produce different amounts of voltage. By using different combinations of metal plates in the same electrolyte we can also produce different amounts of voltage. In the sketch below, A and B are identical, except that a different combination of metals have been put in the electrolyte. Note that the voltage produced by the copper plates and the zinc plates is much higher than the voltage produced by the copper plates and the aluminum plates.



Mark the following true statements with a "T" on the response sheet.

____ 1. Copper and aluminum immersed in water produce a higher voltage than copper and zinc immersed in water.

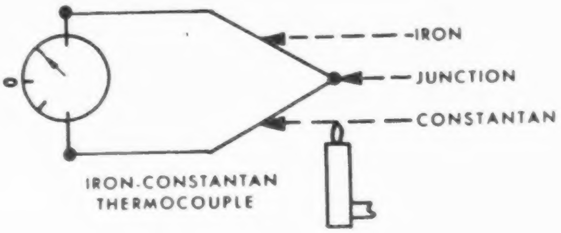
____ 2. Voltage produced by the chemical method can be varied by either using different types of metals, or by the use of different types of electrolyte.

____ 3. In the above illustration, voltage is produced by the mechanical method.

Answers to Frame 8: _____1. __T__2. _____3.

Frame 9

Even though the mechanical and chemical methods are used to produce most of our electrical power, the thermal or heat method of voltage generation also has its uses. This method is used in heat indicating circuits and fire warning systems. The device that is used to produce the voltage is called a thermocouple. In this method when two wires of unlike metals are joined at one end, and heat is put on the junction of these wires, a voltage will be produced. In the sketch shown, one wire is iron, and the other wire is constantan (an alloy of nickel and copper). Heat is applied to the junction (the point at which the two wires are joined together), and the meter that is hooked up to the thermocouple shows that a voltage is generated.



Mark the following true statements with a "T" on the response sheet.

____ 1. A thermocouple is a device used to produce voltage by the heat or thermal method.

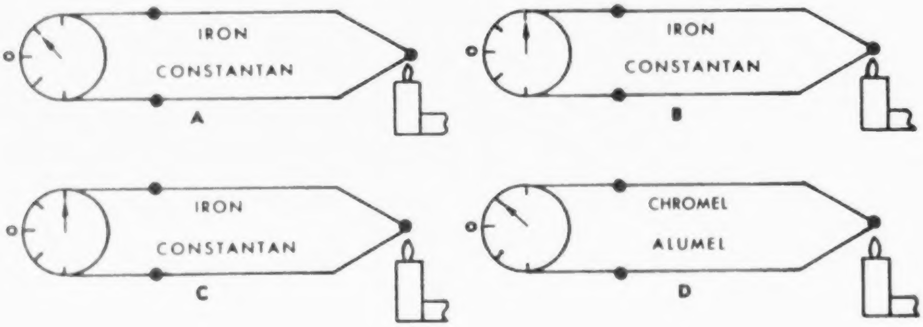
____ 2. The chemical method of producing voltage, changes heat energy to electrical energy.

____ 3. If two dissimilar metal wires joined at one end are heated at their junction, a voltage is generated.

Answers to Frame 9: T 1. ____ 2. T 3.

Frame 10

The voltage made by the thermal method can be changed in two different ways. If the heat is changed, the amount of voltage generated will change. This is why the thermocouple can be used in heat indicating circuits. As the heat goes up, the voltage goes up. As shown in the sketch, a meter can be hooked between the ends of the thermocouple and must be marked in degrees to show the temperature at the thermocouple junction. The other means of getting a different voltage is to use two different metals in the wires. In the sketch shown, A and B are the same thermocouples, but more heat is put on B than is put on A, and the voltage generated by B is higher. C and D are made of different metals. The same amount of heat is put on each, but the iron-constantan thermocouple generates a higher voltage than the chromel-alumel thermocouple.



Mark the following true statement(s) with a "T" on the response sheet.

____ 1. Different metals in thermocouples produce different amount of voltage.

____ 2. Increasing the amount of heat applied to a thermocouple increases the amount of voltage generated.

____ 3. In the illustration, voltage is produced by the chemical method.

____ 4. The thermocouple is used to produce voltage by the mechanical method.

Answers to Frame 10: _T_ 1. _T_ 2. ____ 3. ____ 4.

Frame 11

Match the definitions on the right to the terms on the left. Be sure to distinguish between the device or example and the method. Write your answer on the response sheet.

____ 1. Mechanical method

____ 2. Battery

____ 3. Generator

____ 4. Heat or thermal method

____ 5. Thermocouple

____ 6. Chemical method

a. Device that uses mechanical energy to produce an EMF.

b. Voltage is produced by two dissimilar metals immersed in a solution which will conduct electricity.

c. Voltage is produced by relative angular motion between conductors, and a magnetic field.

d. Device that uses heat to produce an EMF.

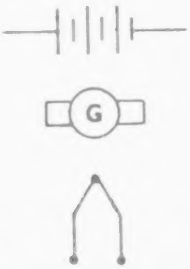
e. Example of the chemical method.

f. Voltage is produced when heat is applied to two dissimilar metals which are joined at one end.

Answers to Frame 11: c 1. e 2. a 3. f 4. d 5. b 6.

Frame 12

By now you should understand that the first part of a basic circuit is the powersource which supplies EMF. Examples of a power source are a battery, generator, and thermocouple. In frame 1, we said that there was a need to know basic symbols in order to trace out the circuits. Symbols are used to make identification of units easier, and to remove thy need for writing the name or drawing a picture of the unit. The schematic symbols for a battery, generator, and thermocouple are shown below.



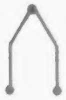
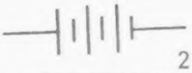
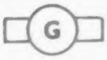
NOTE: Short line is negative, long line is positive.

Draw the correct symbol by its term on the response sheet.

1. Thermocouple __________________.

2. Battery ___________________.

3. Generator _________________.

Answers to frame 12.  ________1.  ________2. 

________3.

Frame 13

The second part of a basic circuit is the load unit. This is a device which needs current to perform a task. Some examples are lamps, motors, resistors, and coils. For now, we will be concerned mainly with lamps and resistors.

Mark the following true statements with a "T" on the response sheet.

____ 1. A load unit performs its function by using current.

____ 2. A motor is an example of a load unit.

____ 3. A thermocouple is an example of a source of EMF.

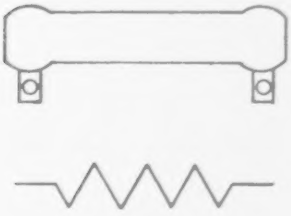
____ 4. A resistor is a source of EMF.

____ 5. A lamp is a protective device.

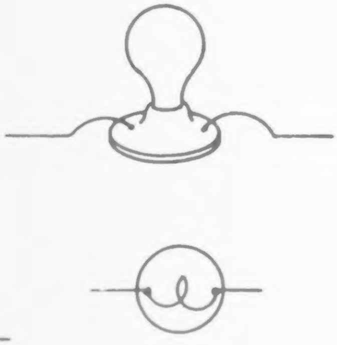
Answers to Frame 13: T 1. T 2. T 3. ___4. ___5.

Frame 14

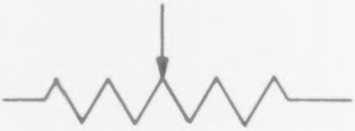
Some examples of load units and their symbols are shown below:



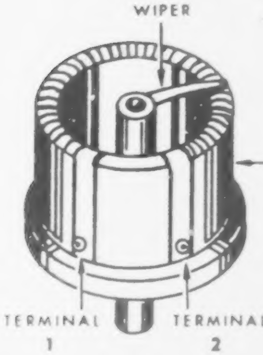
FIXED RESISTOR



LAMP



SYMBOL FOR A RHEOSTAT OR A VARIABLE RESISTOR



COLORED LAMPS ARE DESIGNATED AS FOLLOWS:

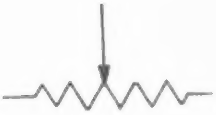
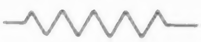
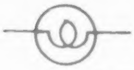
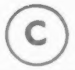
Ⓒ CLEAR LAMP

Ⓡ RED LAMP

Ⓨ YELLOW LAMP

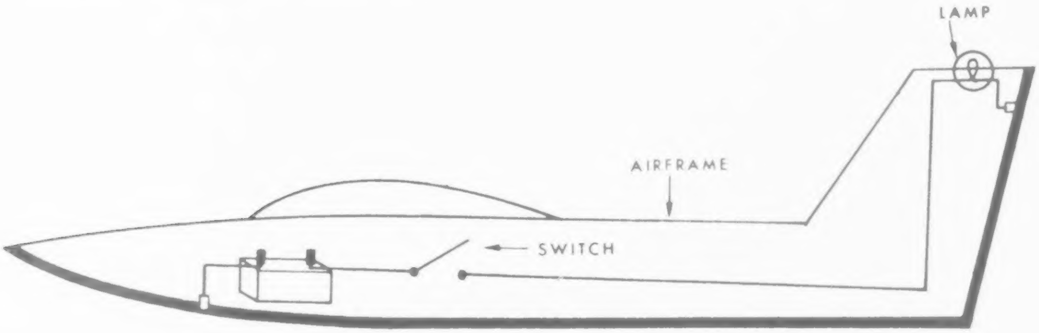
Draw the correct symbols beside their terms on the response sheet.

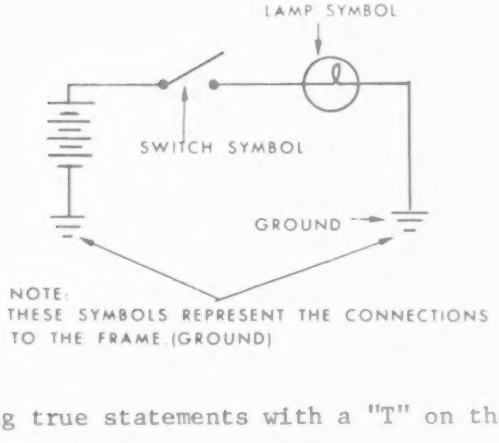
1. Variable resistor or rheostat ____________________
2. Fixed resistor ____________________
3. Lamp ____________________
4. Clear lamp ____________________

Answers to frame 14.  1.  2.  3.  4.

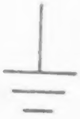
Frame 15

A third part of a basic circuit is a conductor. This is the part that is used to form the path that current will follow. A wire is the most common kind of a conductor used. The schematic symbol for a wire is a solid line. The metal frame of the aircraft can also be used as a conductor (wire). To simplify a circuit, the metal frame is used as one of the paths for electron flow. This mode will also cut down the weight of the aircraft by cutting down the amount of wiring the aircraft mus have. When the switch in the sketch below is closed the circuit is completed. Electrons will flow from the battery to the aircraft frame, through the frame to the lamp ground wire, and on to the lamp. From the lamp they move on through the wire; to and through the switch to the battery. A schematic diagram of this is shown below.


LAMP
AIRFRAME
SWITCH


LAMP SYMBOL
SWITCH SYMBOL
GROUND
NOTE:
THESE SYMBOLS REPRESENT THE CONNECTIONS
TO THE FRAME (GROUND)

Mark the following true statements with a "T" on the response sheet.

____ 1.  is a ground connection symbol.

____ 2. The aircraft structure is used as a conductor.

____ 3. A wire is the only conductor used in the aircraft.

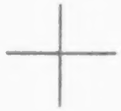
____ 4. The case of some units is used as a conductor.

Answers to Frame 15: T 1. T 2. ___3. T 4.

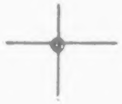
Frame 16

Below are the symbols widely used to indicate connection or no connection of conductors.

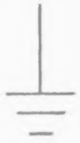
1. Crossing (no connection.)



2. Connection.



3. Ground connection.

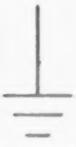
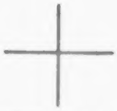
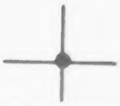


Draw the correct symbol beside its name on the response sheet.

1. Ground connection ____________________.

2. Crossing (no connection) ____________________.

3. Connection ____________________.

Answers to frame 16.  1.  2.  3.

Frame 17

Let's check to see how much you have learned.

I. Match the terms on the right with the components on the left. Some terms will be used more than once. Write your answers on the response sheet.

____ 1. Motor

____ 2. Battery

____ 3. Wire

____ 4. Resistor

____ 5. Thermocouple

____ 6. Aircraft structure

____ 7. Case of a unit

____ 8. Generator

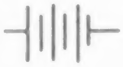
____ 9. Lamp

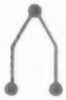
a. Load unit

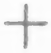
b. Conductor

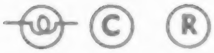
c. Source of EMF.

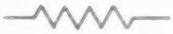
II. Match the terms on the right with the symbols on the left. Write your answers on the response sheet.

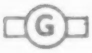
____ 1. 

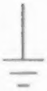
____ 2. 

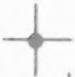
____ 3. 

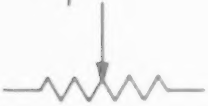
____ 4. 

____ 5. 

____ 6. 

____ 7. 

____ 8. 

____ 9. 

a. Generator

b. Lamps

c. Thermocouple

d. Variable resistor

e. Conductors connected

f. Ground

g. Resistor fixed

h. Battery

i. Conductors crossing (no connection)

If you missed any of the above, review the appropriate frame before proceeding with frame 18.

If you got them all correct, proceed with frame 18.

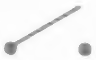
Answers to Frame 17:

Section I: a 1. c 2. b 3. a 4. c 5. b 6. b 7. c 8. a 9.

Section II: h 1. c 2. i 3. b 4. g 5. a 6. f 7. e 8. d 9.

Frame 18

So far we have gone over three parts of a basic circuit. We have two more parts left, a controlling device and a protective device. The controlling device is used to turn the circuit ON and OFF. Switches and relays are used for this purpose. The relay is used as a remote control type of switch. You have used a switch each time you turned your room light on and off. There are a lot of different types of switches and relays that will be gone over in a later lesson. For the present, remember that relays and switches are controlling devices. Shown here is the symbol for a basic switch.



Mark the following true statements with a "T" on the response sheet.

____ 1. The relay is the only controlling device that you will use.

____ 2. The symbol for a switch is

____ 3. A controlling device is used to turn a circuit ON and OFF.

____ 4. A switch is a controlling device.

Answers to Frame 18: ____ 1. T 2. T 3. T 4.

Frame 19

To close a switch means to turn the switch to a position which will allow current to flow through it. Thus, to open a switch means to turn the switch to a position which will no allow current to flow through it.

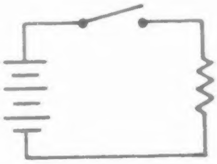


Figure 1.

In figure 1 we have a source of EMF (power), conductor, load unit, and a controlling device. Note that the switch is open. Thus, we have a circuit which will not have a complete path for current flow. Now if we close the switch, as in figure 2, we will have a complete path for current to flow to the load.

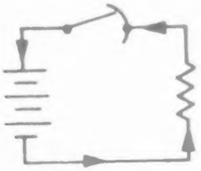


Figure 2.

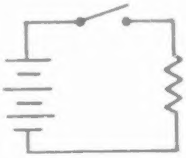


Figure 3.

Mark the following true statements with a "T" on the response sheet.

____ 1. In figure 3, there is a complete path for current flow.

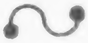
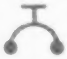
____ 2. In figure 3, if the switch is closed there will be a complete path for current flow.

____ 3. Figure 3 shows a complete circuit of a switch, conductor, resistor, and a generator.

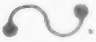
Answers to Frame 19: ___1. _T_2. ___3.

Frame 20

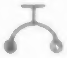
The fifth and last part of a basic circuit is a protective device. It is used to protect the circuit against too high a current flow. Two examples of protective devices are fuses and circuit breakers. The main difference between the two is that a circuit breaker can be reset and reused, while a fuse cannot and must be replaced if blown. There are many types of fuses and circuit breakers. You will study these in a later lesson.

The basic symbol for a fuse is  . The symbol for one type of circuit breaker, the push-pull is  .

Mark the following true statements with a "T" on the response sheet.

____ 1. The symbol for a fuse is .

____ 2. A fuse can be reset.

____ 3. The symbol for a push-pull circuit breaker is  .

____ 4. A protective device protects the circuit from an under-voltage condition.

____ 5. Fuses and circuit breakers are protective devices.

Answers to Frame 20: _T_1. ___2. _T_3. ___4. _T_5.

Frame 21

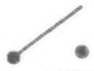
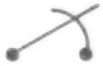
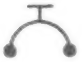
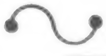
Draw the correct symbol beside its name on the response sheet.

1. Switch open ____________________.

2. Switch closed ____________________.

3. Push-pull circuit breaker ____________________.

4. Fuse ____________________.

Answers to frame 21.  1.  2.  3.  4.

Frame 22

In the lesson you had on Electron Theory EMF, Current, and Resistance was defined. In this frame we will review the definitions of EMF and current and add some other facts you need to know about them.

EMF is the force that is needed to cause current to flow. EMF is the abbreviation for electromotive force. There are other terms which have almost the same meanings, like voltage, potential difference, and electrical pressure. The symbol we use for all these terms is E. The unit of measurement of EMF is the volt. One voltis the pressure that is required to send one ampere of current through a resistance of one ohm. The symbol for volt is V.

Current was defined as the flow of electrons through a conductor from a negative potential to a positive potential. Again it must be said that there are terms that have just about the same meaning as current. These are electron flow, intensity, and amperage. The symbol for all these terms is I. The unit of measurement for current is the ampere. The symbol for ampere is a.

Place the symbol in the blank space on the response sheet for each of the following terms.

______ 1. electromotive force

______ 2. current

______ 3. volt

______ 4. potential difference

______ 5. ampere

______ 6. voltage

Answers to Frame 22: E 1. I 2. V 3. E 4. a 5. E 6.

Frame 23

Resistance is the opposition to current flow in a dc circuit. The symbol for resistance is R. The unit of measurement of resistance is the ohm. One ohm is the value of resistance through which 1 ampere of current will flow when one volt is applied to it. The symbol for ohm is the Greek letter omega, written as Ω.

Mark the following true statements with a "T" on the response sheet.

____ 1. Resistance is the opposition to current flow in a DC circuit.

____ 2. The symbol for resistance is Ω.

____ 3. The unit of measurement for resistance is omega.

____ 4. The symbol for ohm is Ω.

Answers to Frame 23: T 1. ____2. ____3. T 4.

Frame 24

Match the symbols on the right with the terms on the left and write the answers on the response sheet.

____1. Volt
____2. Ohm
____3. Resistance
____4. Current
____5. Ampere
____6. Voltage

a. EE
b. V
c. R
d. a
e. Ω
f. I

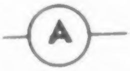
If you miss any of these, restudy frames 22 - 23 before proceeding to frame 25.

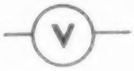
If you got these all correct, proceed to frame 25.

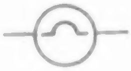
Answers to Frame 24: b 1. e 2. c 3. f 4. d 5. a 6.

Frame 25

The amount of voltage, current, and resistance in a circuit is based on the type of circuit. For measuring these values we use meters. To measure current flow we use an ammeter, to measure potential difference we use a voltmeter, and to measure resistance, we use an ohmmeter. The use of these meters will be the topic of another lesson. For now we are concerned only with the symbols for these meters. They are as follows:

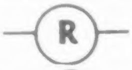
1. Ammeter 

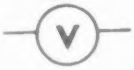
2. Voltmeter 

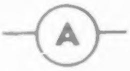
3. Ohmmeter 

Mark the following true statements with a "T" on the response sheet.

____ 1. An ohmmeter is used to measure current flow in a circuit.

____ 2. The symbol for the ohmmeter is  .

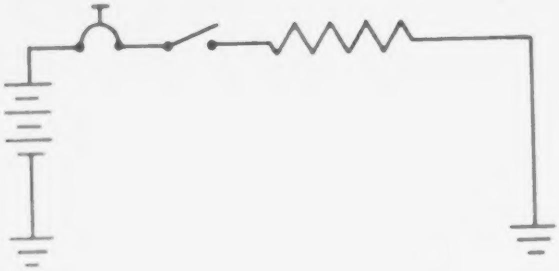
____ 3. The symbol for the voltmeter is  .

____ 4. The symbol for the ammeter is  .

Answers to Frame 25: ___1. ___2. T 3. T 4.

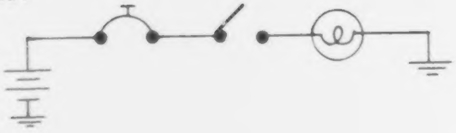
Frame 26

Now let's combine some of the symbols you have learned and draw a basic circuit.



Now you will draw a basic circuit on the response sheet with a battery, conductor, circuit breaker, switch, and a lamp, not a resistor as shown above.

Answer to Frame 26:



Frame 27

Match the terms on the right with the components on the left. The terms can be used more than once. Write your answers on the response sheet.

_____1. Wire

_____2. Aircraft structure

_____3. Resistor

_____4. Relay

_____5. Motor

_____6. Lamp

_____7. Switch

_____8. Case of unit

_____9. Generator

____10. Thermocouple

____11. Fuse

____12. Battery

____13. Circuit breaker

a. Load unit

b. Source of EMF

c. Conductor

d. Protective device

e. Controlling device

If you missed any of these, restudy the appropriate frame dealing with the question or questions you missed before proceeding with frame 28.

If you got these all correct, proceed with frame 28.

Answers to Frame 27: c 1. c 2. a 3. e 4. a 5. a 6. e 7.

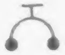
c 8. b 9. b 10. d 11. b 12. d 13.

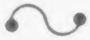
Frame 28

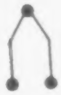
Match the terms on the left with the symbols on the right. Write your answers on the response sheet.

_____1. Generator
_____2. Thermocouple
_____3. Volt
_____4. Variable resistor
_____5. Ammeter
_____6. Ground
_____7. Fixed resistor
_____8. Voltage
_____9. Battery
____10. Ohmmeter
____11. Resistance
____12. Lamps
____13. Current
____14. Ohm
____15. Voltmeter
____16. Conductors connected
____17. Ampere
____18. Circuit breaker
____19. Conductors crossing
____20. Switch
____21. Fuse

a. Ω
b. a
c. V
d. R
e. E
f. I

g.


h.


i.


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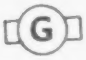
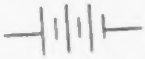
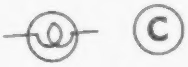
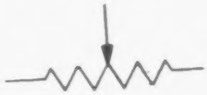
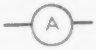
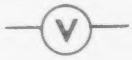


k.


l.


m.


n.


o.


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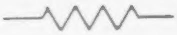
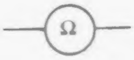
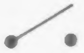


q.


r.


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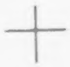
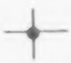
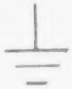


t.


u.


If you missed any of these, restudy the frame covering that symbol or symbols before proceeding to frame 29.

Answers to Frame 28: j 1. i 2. c 3. m 4. n 5. u 6. p 7.
e 8. k 9. g 10. d 11. e 12. f 13. a 14.
o 15. t 16. b 17. q 18. s 19. r 20. h 21.

Frame 29

Match the definitions on the right to the terms on the left. Be sure to distinguish between the device or example and the method.

_____1. Chemical method
_____2. Thermocouple
_____3. Generator
_____4. Heat or thermal method
_____5. Battery
_____6. Mechanical method

a. Device that uses mechanical energy to produce an EMF.

b. Voltage is produced by two dissimilar metals immersed in a solution that will conduct electricity.

c. Voltage is produced by relative angular motion between conductors and a magnetic field.

d. Device that uses heat to produce an EMF.

e. Example of the chemical method of producing an EMF.

f. Voltage is produced when heat is applied to two dissimilar metals which are joined at one end.

If you missed any of these, restudy frames 2 - 11.

Answers to Frame 29: b 1. d 2. a 3. f 4. e 5. c 6.

PROGRAMMED TEXT
3ABR42331-PT-110

Technical Training

Aircraft Environmental Systems Mechanic

WIRING DIAGRAM FUNDAMENTALS

2 September 1980

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 9.6

OBJECTIVES

Select five (5) of the six (6) elements that make up the wire numbering system.

Select common symbols of wiring diagrams, with a minimum of 80% accuracy.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." Read the material presented, select your response(s) at the end of the frame as required. Do not mark in the text. Enter your response(s) on the response sheet provided. After you have made your selections check your work against the answers on the following page. If your selections were correct, go on to the next frame and repeat the above process. If you have made an incorrect response, reread the frame until you understand your error and/or see your instructor. After you complete the text and response sheet see your instructor for the appraisal test.

Supersedes 3ABR42331-PT-110, 25 January 1979.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; TTVSA - 1

Many miles of electrical wire are used to connect the various units into operational systems. These wires are the connecting links between the source of power and the unit requiring power. By placing a number of these wires, units, and circuits together a wiring diagram is formed. As a mechanic, you will be called upon to use and interpret these wiring diagrams; that is, identify the symbols used, identify the wires, and trace the electrical systems. Wiring diagrams can help you gain an understanding of how the system works. Wiring diagrams are also a valuable aid in troubleshooting the electrically operated portions of the numerous systems that make up the aircraft control systems.

Place the letter T beside each of the following true statements.

_____1. Training on the proper use and interpretation of wiring diagrams is important to you because you will have to check aircraft circuits.

_____2. A wiring diagram on an aircraft air conditioning system will help you troubleshoot the system.

_____3. To be able to use a wiring diagram efficiently you must be able to identify the symbols, identify the wire, and trace a wire that is used to operate a unit.

Answers to Frame 1: 1. T 2. T 3. T

Frame 2

Some AN connectors are shown below in illustration #1. They are used where an electrical unit must be removed and reinstalled easily and quickly. These connectors consist basically of a plug, a receptacle, and a coupling nut which holds the unit together. Both the plug and receptacle consist of an aluminum shell containing an insulated insert which holds the contact points. The symbols shown in illustration #2 below are used on electrical wiring diagrams to illustrate the AN connectors. The symbols in illustration 2A and 2B are used on some diagrams to illustrate the plug and receptacle on some connectors. The symbol shown in illustration 2C is also used to illustrate the plug and receptacle of these connectors. The letter in front of each connector number denotes whether it is a plug or receptacle, P standing for plug and J standing for receptacle.

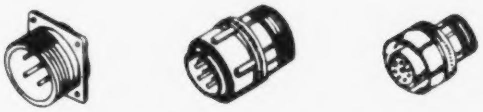


ILLUSTRATION #1

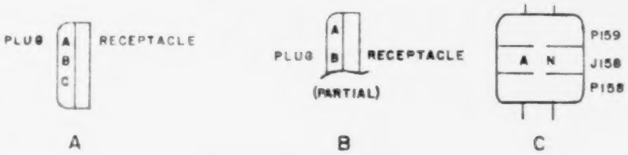


ILLUSTRATION #2

Place the letter T beside each of the following true statements.

______1. Symbols are used on wiring diagrams to indicate the components required in the electrical system.

______2. In connector number P159, the letter P indicates that this section of the connector is a receptacle.

______3. Connector plugs and receptacles are used where an electrical unit must be removed and reinstalled easily and quickly.

Answers to Frame 2: 1. T 2. F 3. T

Frame 3

A terminal block (strip) and terminal are shown below in illustration 1. There is a single row of terminal posts (studs) set in some insulating material. This is shown in illustration #2. Terminal strips are used to connect wires going to one unit and to parallel electrical circuits when one source of power is used for more than one circuit. The symbol for a terminal block (strip) is shown in illustration 2. Terminal block (strips) are usually located in an enclosed distribution box called a Junction Box.

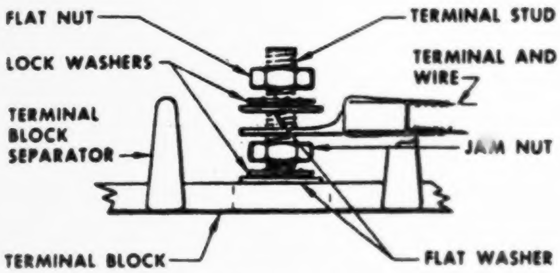

FLAT NUT
TERMINAL STUD
LOCK WASHERS
TERMINAL AND WIRE
TERMINAL BLOCK SEPARATOR
JAM NUT
TERMINAL BLOCK
FLAT WASHER

Illustration #1

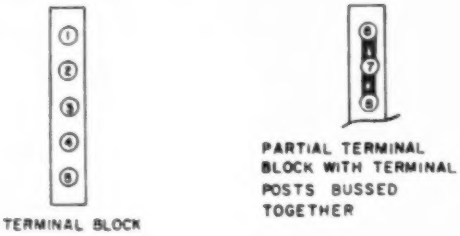

TERMINAL BLOCK
PARTIAL TERMINAL BLOCK WITH TERMINAL POSTS BUSSED TOGETHER

ILLUSTRATION #2

Place the letter T beside each of the following true statements.

_____1. Terminal blocks (strips) are used where an electrical unit must be removed and reinstalled easily and quickly.

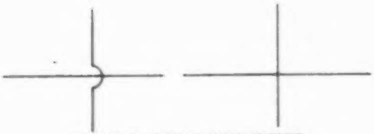
_____2. The terminal posts on a terminal strip can be bussed (connected) together.

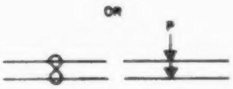
_____3. A terminal block (strip) is a single row of studs mounted in a terminal block which is made of some insulating material.

Answers to Frame 3: 1. F 2. T 3. T

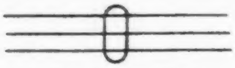
Frame 4

The symbols shown in the illustration below are used on wiring diagrams to indicate the conductors. The symbol for the cable assembly indicates the wires that are bound together in the same wiring harness or bundle. Some bundles may be as thick as a man's arm while others may be made up of only two cables. Wire bundles are used throughout the aircraft to minimize battle damage and to speed manufacturing of the aircraft.


CROSSING PATHS CONDUCTORS



TWISTED CONDUCTORS


CABLE ASSEMBLY

Place the letter T beside each of the following statements that are true.

_____ 1. As little as two wires can be used to make up a wire bundle.

_____ 2. Two conductors can be twisted together.

Answers to Frame 4: 1. __T__ 2. __T__

Frame 5

Match the symbols in column B with the identifying name for that symbol in column A.

Column A

_____1. Crossing paths conductors

_____2. Twisted conductors

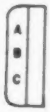
_____3. Terminal block

_____4. AN connector

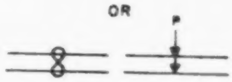
_____5. Cable assembly

Column B

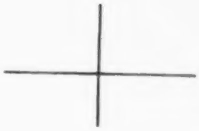
A



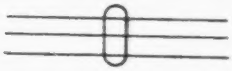
B



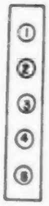
C



D



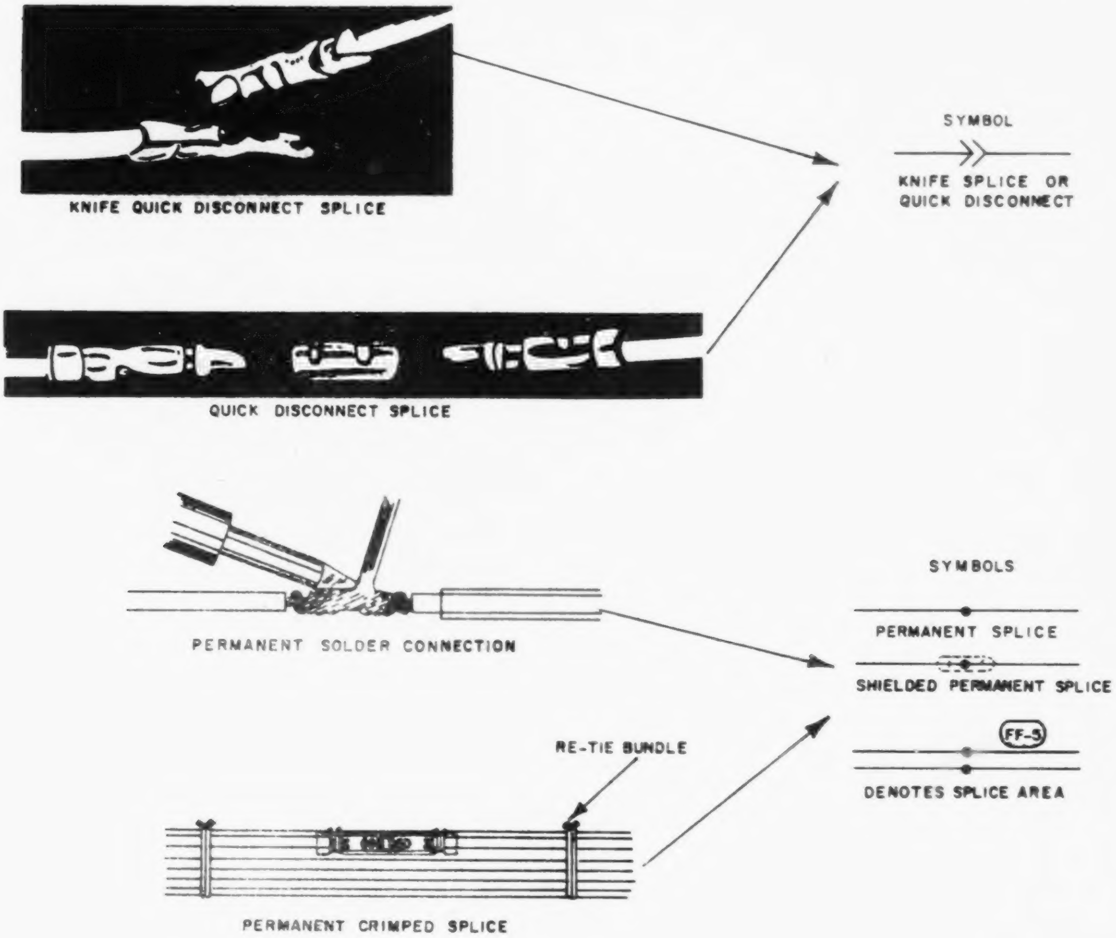
E



Answers to Frame 5: 1. C 2. B 3. E 4. A 5. D

Frame 6

A cable splice is a means of joining two pieces of cable together. The splice can be a permanent or quick disconnect type. The solder splice and the crimped splice can be used to repair a broken wire. The illustration below shows the different types of splices and the symbols that are used for them.


KNIFE QUICK DISCONNECT SPLICE
SYMBOL
KNIFE SPLICE OR QUICK DISCONNECT
QUICK DISCONNECT SPLICE
SYMBOLS
PERMANENT SPLICE
SHIELDED PERMANENT SPLICE
FF-5
DENOTES SPLICE AREA
PERMANENT SOLDER CONNECTION
RE-TIE BUNDLE
PERMANENT CRIMPED SPLICE

1. Draw the symbol used for a knife splice.

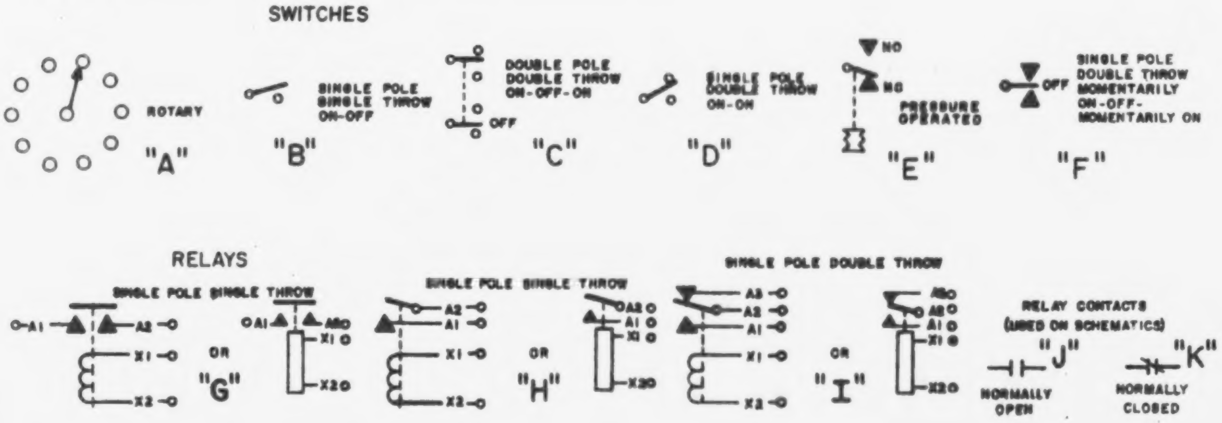
2. Draw the symbol used for a permanent splice.

Answers to Frame 6: 1. ——› ›—— 2. ——•——

Frame 7

Symbols are used to represent the various types of switches and relays that control the electrical circuit operation. These symbols are shown in the illustration below. The relays are shown in the de-energized position. When the relay is energized, the armature of the relay (heavy black line connected to the dashed line) will move down. The symbols shown for the relay contacts are used on schematic diagrams and are being used more extensively. These symbols make it easier for you to follow the path of current flow through an electrical circuit.

Note: See instructor for display 9.


SWITCHES
ROTARY
"A"
SINGLE POLE SINGLE THROW ON-OFF
"B"
DOUBLE POLE DOUBLE THROW ON-OFF-ON
OFF
"C"
SINGLE POLE DOUBLE THROW ON-ON
"D"
NO
NC
PRESSURE OPERATED
"E"
OFF
SINGLE POLE DOUBLE THROW MOMENTARILY ON-OFF-MOMENTARILY ON
"F"
RELAYS
SINGLE POLE SINGLE THROW
A1
A2
X1
X2
OR
"G"
SINGLE POLE SINGLE THROW
A2
A1
X1
X2
OR
"H"
SINGLE POLE DOUBLE THROW
A3
A2
A1
X1
X2
OR
"I"
RELAY CONTACTS (USED ON SCHEMATICS)
"J"
NORMALLY OPEN
"K"
NORMALLY CLOSED

Match a letter from the illustration above to each of the statements below.

_____1. A switch that can be used to turn one circuit on or off.

_____2. A switch requiring one source of power capable of turning either one of two electrical circuits on and off.

_____3. A relay that can control two electrical circuits.

_____4. A normally open relay contact.

_____5. A switch that can control ten electrical circuits.

Answers to Frame 7: 1. B 2. D 3. I 4. J 5. A

Frame 8

Place the letter of the symbol from column B beside the correct name for that symbol in column A.

Column A

_____1. Splice area

_____2. Rotary switch

_____3. Single pole double throw relay

_____4. Knife splice or quick disconnect

_____5. Single pole single throw relay

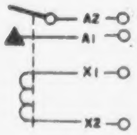
_____6. Single pole single throw switch

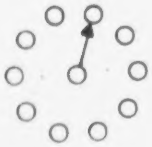
_____7. Single pole double throw switch

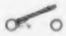
_____8. Double pole double throw switch

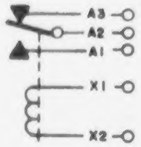
_____9. Permanent splice

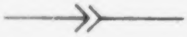
Column B

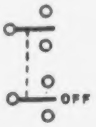
A


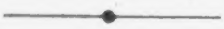
B


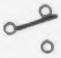
C


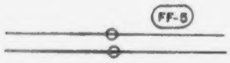
D


E


F


G


H


I


Answers to Frame 8: 1. J 2. B 3. D 4. E 5. A

6. C 7. H 8. F 9. G

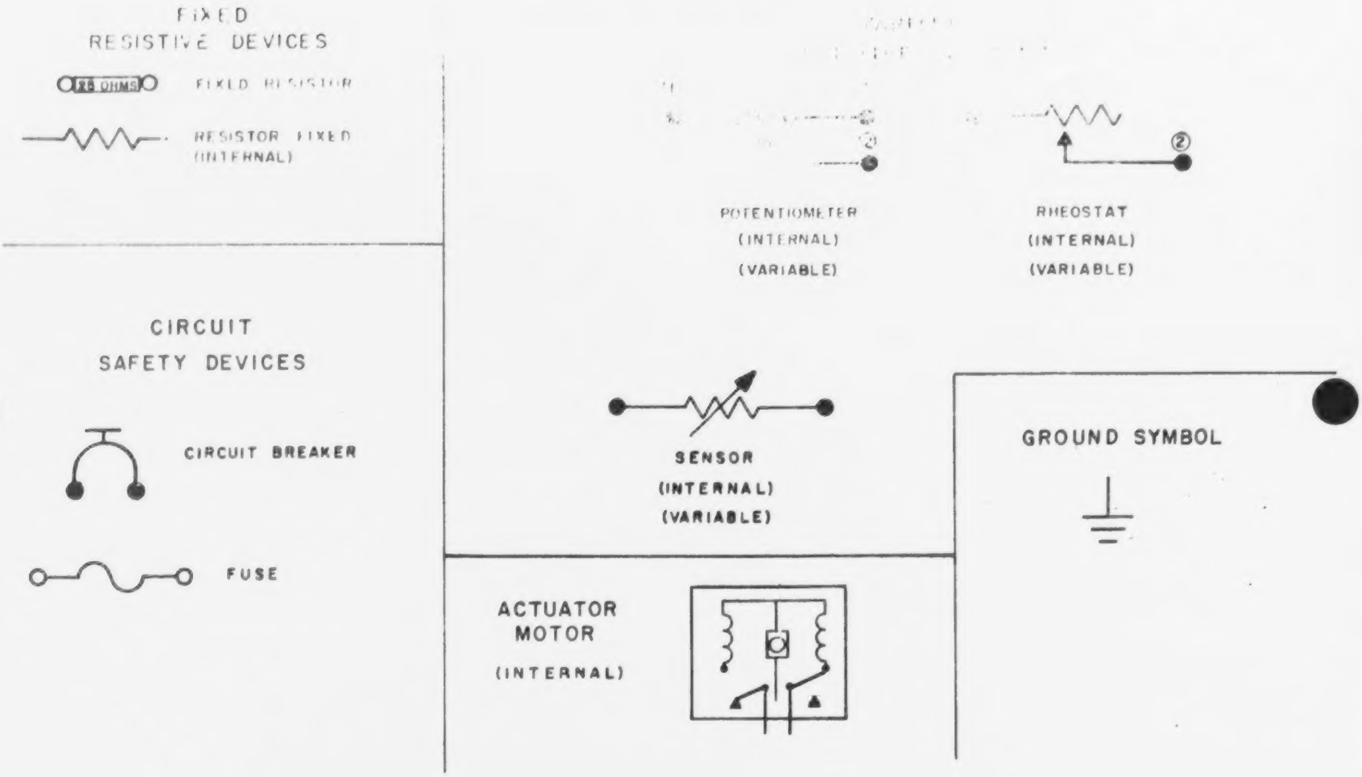
Frame 9

The illustration below shows some of the other symbols you will see as you look at a wiring diagram. Becoming familiar with these symbols will help you read a wiring diagram.

Note: See instructor for display 10.

Circuit Elements

RESISTIVE DEVICES

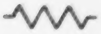

FIXED RESISTIVE DEVICES
25 OHMS
FIXED RESISTOR
RESISTOR FIXED (INTERNAL)
②
POTENTIOMETER (INTERNAL) (VARIABLE)
②
RHEOSTAT (INTERNAL) (VARIABLE)
CIRCUIT SAFETY DEVICES
CIRCUIT BREAKER
FUSE
SENSOR (INTERNAL) (VARIABLE)
GROUND SYMBOL
ACTUATOR MOTOR (INTERNAL)

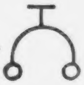
Using the illustration above, draw the symbols that represent each of the following units.

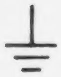
1. Internal view of a fixed resistor.
2. Push-pull type circuit breaker.
3. Ground symbol.
4. Internal view of a potentiometer.
5. Fuse.
6. Internal view of a rheostat.
7. View of a sensor.

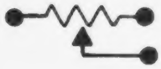
BEST COPY AVAILABLE

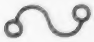
Answers to Frame 9:

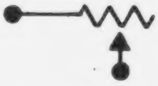
1.


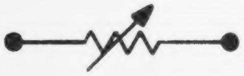
2.


3.


4.


5.


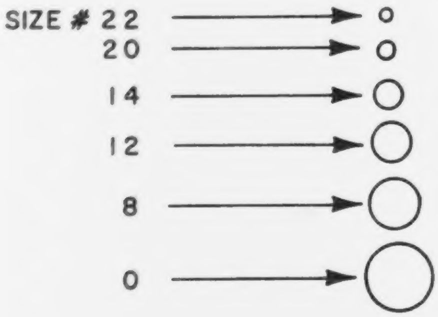
6.


7.


Frame 10

Illustrated below is an example of how wires are sized. If a wire is to carry a large amount of current it must be a large wire. These are not drawn to scale but simply represent the difference in sizes and the manner in which they are numbered or "sized."

Note: See instructor for display 8.



It is impossible to cover every symbol that you will find on aircraft wiring diagrams. Each aircraft has a technical manual which is referred to as a wiring diagram handbook which contains the symbols that will be used on the aircraft's wiring diagrams. It is a good idea to review these symbols so that reading the diagram will have meaning to you.

Place the letter T beside each of the following statements that are true.

_____1. The symbols used on an aircraft wiring diagram can be found in the wiring diagram handbook for that particular aircraft.

_____2. A wiring diagram will have meaning if you can interpret the symbols that are used.

PROGRAMMED TEXT
3ABR42331-PT-111

Technical Training

Aircraft Environmental Systems Mechanic

CONTROL AND PROTECTIVE DEVICES

9 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: 9.7

OBJECTIVES

1. Specify the control devices used in electrical circuits with a minimum accuracy of 80%.

2. Select the protective device symbols used in electrical circuits with a minimum of 80% accuracy.

INSTRUCTION

Read each frame carefully, beginning with the first frame. Answer the questions at the end of each frame according to the instructions provided in each frame. Check your answers by comparing your response with the correct answers which are found on top of the following page. If you made an error, determine the cause of your error, and correct it before going on to the next frame. When you complete this lesson, contact your instructor for further instructions. Do not mark in this text. Write your answers on the response sheet.

Supersedes 3ABR42331-PT-105C, 17 August 1977.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; TTVSA - 1

Control and protective devices are very important parts in an electrical circuit. Control devices are used to control the paths for the flow of current. Protective devices are used to protect units and wiring in the event the load is too large. These types of devices are used in your houses as well as in aircraft. These devices are identified by symbols in schematic diagrams since it would be difficult to draw in a picture of each device. It is very important that you learn all about them and associate these devices by name, symbol, and their purpose in a circuit. Let us see what you already know about control and protective devices.

DO NOT MARK IN THIS TEXT

Mark the correct answer for each of the following questions on the response sheet.

____1. An example of a protective device is a

a. switch.
b. fuse.

____2. A fuse is used for the same purpose as a

a. switch.
b. circuit breaker.

____3. If a fuse is wrapped with tin foil, it will provide protection for the circuit.

a. True
b. False

____4. Switches are used

a. to control circuits.
b. as protective devices.

____5. Circuit breakers are used

a. to control circuits.
b. as protective devices.

Answers to Frame 1: _b_ 1. _b_ 2. _b_ 3. _a_ 4. _b_ 5.

Frame 2

If you have answered all of the questions correctly in frame 1, this shows that you do know a little about control and protective services. But, let us take a more detailed look at these units. We will start with the control devices. Control devices are known as switches. Although there are hundreds of types of switches, all of them can be grouped in one of four types. The four types of switches are manual, mechanical, magnetic operating types and electronic devices. We will study the first three in this text. The fourth, an electronic device, will be studied later.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on the response sheet.

_____1. A magnetic switch is a circuit control device.

_____2. Fuses are used to control a circuit.

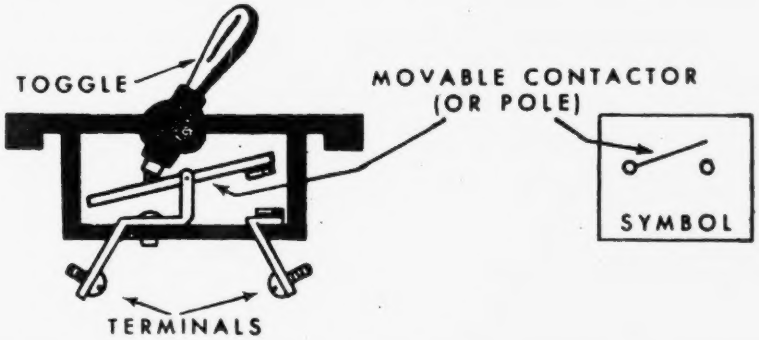
_____3. There are hundreds of classes of control devices.

_____4. Control devices are used to control paths for current to flow.

Answers to Frame 2: T 1. _____2. _____3. T 4.

Frame 3

Let us study the manual switches first. A sample of a SPST switch can be found in display board number nine in your classroom. The most common type of manual switch is known as the toggle switch. This switch has a toggle which you must operate manually to open or close the switch internal electrical path. When we say manually, it means you must physically move the toggle. Let us take a look at a simple toggle switch. If we learn the principles of this switch, they can be used for all toggle switches, shown here.



All toggle switches have poles. A pole is the movable contactor. Since the switch above has only one movable contactor, it is known as a single pole (SP) switch. When the toggle is moved to the other position, it pushes the pole down to make contact with the terminal on the right, completing the circuit to both terminals.

DO NOT MARK IN THIS TEXT

Mark the correct answer for each of the following questions on the response sheet.

_____1. When the toggle is moved to the ON position the poles which are internal contacts are

a. close.
b. open.

_____2. Poles are also known as

a. positions.
b. terminals.

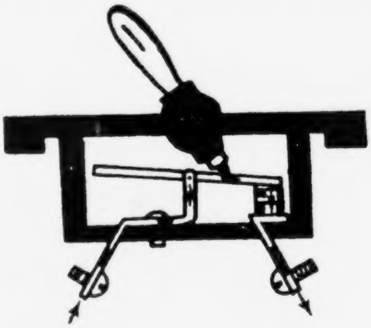
_____3. The switch above is shown in the

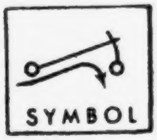
a. closed position.
b. open position.

Answers to Frame 3: a 1. b 2. b 3.

Frame 4

Switches also have movements called throws. This means the number of "ON" positions the switch has, which means the number of paths where current can flow. In the switch below there is only one ON position or one path for current to flow. Therefore, this is known as a single throw (ST) switch. Notice the symbol below on the right. This is the way we show, on a schematic diagram, that the switch is closed.





Notice that there is now a complete path for current flow through the switch. This path is shown by a series of arrows in the above switch.

DO NOT MARK IN THIS TEXT

Mark the following true statement with a "T" on the response sheet.

_____1. The switch above is known as a SPST toggle switch.

_____2. The number of throws a switch has is equal to the number of terminals on the bottom of the switch.

_____3. The switch above is shown in the CLOSED or ON position.

_____4. SPST stands for simple polarized switch terminals.

Answers to Frame 4: _T_ 1. ___ 2. _T_ 3. ___ 4.

Frame 5

To make a complete identification of a toggle switch, there is one more thing you should know. That is the number of positions it has. The switch shown in frames 3 and 4 has only two positions; they are, one "ON" position, and the other is the "OFF" position.

DO NOT MARK IN THIS TEXT

Choose one of the answers provided and write its letter on the response sheet.

1. The switch you have learned about so far can be completely identified by calling it a

   a. SPST 2-position knife switch.
   b. SPDT 2-position toggle switch.
   c. SPST 2-position toggle switch.
   d. SPST 3-position toggle switch.

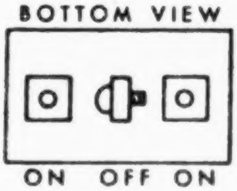
Use frame 35 to answer the following question on the response sheet. The blank may require more than one number.

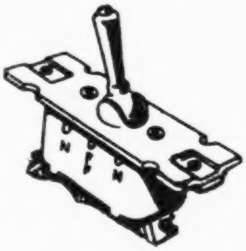
2. SPST toggle switches are identified by what number(s) in frame 35?

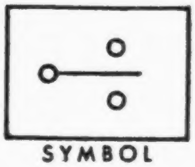
Answers to Frame 5: 1. c 2. 1,3,6

Frame 6

Now let us look at another manual switch. Apply the same things you have already learned, and see if you can figure out how it works in a circuit. Be sure and look at the symbol which represents this switch. See display #9 in your classroom.







DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on the response sheet.

_____1. The above switch has two positions.

_____2. The above switch has two throws.

_____3. The above switch is a toggle switch.

_____4. The above switch could be classified as a double pole switch.

_____5. The above switch could be used to complete two circuits, but not at the same time.

Choose one of the answers provided and write its letter on the response sheet.

6. The switch above could be identified completely by saying it is a

   a. DPDT, 3-position toggle switch.
   b. SPDT, 3-position toggle switch.
   c. DPDT, 2-position toggle switch.
   d. SPST, 3-position toggle switch.

Use frame 35 to answer the following question on the response sheet. The blank may require more than one number.

7. SPDT 3-position toggle switches are identified by what number(s) in frame 35?

Answers to Frame 6: _____1. __T__2. __T__3. _____4. __T__5.
6. b 7. 9 & 11

Frame 7

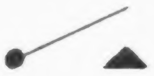
There are other switches which act almost like a normal SPST, SPDT, etc., but are called momentary throws. This means that one or more of the throws is spring loaded to the OFF position.

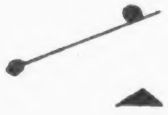
DO NOT MARK IN THIS TEXT

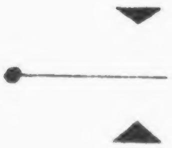
Mark the following true statements with a "T" on the response sheet.

_____1. When the switch is placed to one of the ON positions and released, it springs back to the OFF position.

The symbols below indicate that there are momentary thows in only the direction of the triangle.



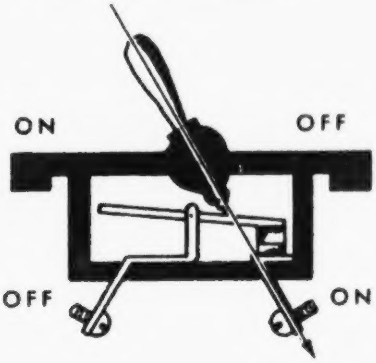


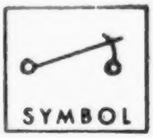


Answers to Frame 7: __T__ 1.

Frame 8

Since you are not able to look inside a switch to figure out how many poles it has in it, there is a way you can find out. Place a toggle switch in any of the ON positions. Now draw an arrow through the center of the toggle, and count the number of terminals it points to. Look at the illustration shown.





Since the arrow points to only one terminal, this is a SP switch. If there were two terminals in a row, it would be a DP switch, etc. Sometimes the switch positions are marked on the switch case. The marks show the position of the toggle. We can tell which terminal will match one or the other of either of the positions by using the same arrow as above. Look and see that the switch is in the ON position. The arrow points to the ON terminal.

DO NOT MARK IN THIS TEXT

Mark the correct answer for each of the following questions on the response sheet.

_____1. The ON terminal at the bottom of the switch above is on the

a. opposite side of the ON position of the toggle.
b. same side of the ON position of the toggle.

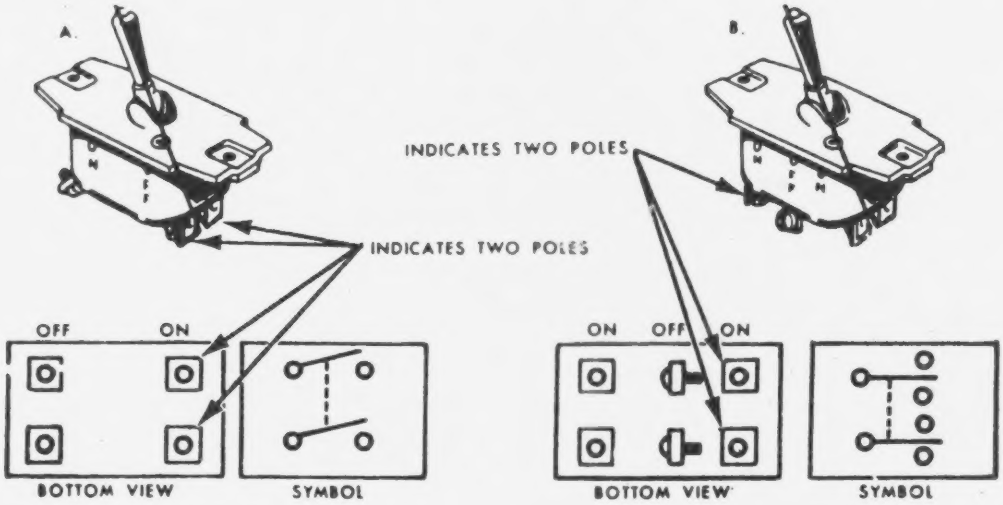
_____2. If the switch is in the ON position, and it points to a row of three terminals, we have a

a. double pole (DP) switch.
b. triple pole (TP) switch.

Answers to Frame 8: a 1. b 2.

Frame 9

Now let us look at some toggle switches and see if you can identify them.



The dashed lines between the poles on the symbols mean that the two poles are mechanically linked together. If you move the toggle to the ON position, both poles go to the ON position. Notice the ON and OFF positions are marked on the switch case, and arrow through the center of the toggle points to the terminals which match up with the toggle ON position. Study the DPDT in display #9 in your classroom.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on the response sheet.

_____1. The switch in figure A is a DPST, 2-position toggle switch.

_____2. The toggle in figure A points to two poles.

_____3. The switch in figure A is a 3-position switch.

_____4. The switch in figure B is a DPDT, 2-position toggle switch.

_____5. The switch in figure B is a 4-pole toggle switch since the total number of terminals in ON positions is four.

_____6. The switch in figure B is a 3-position switch.

Frame 9 (continued)

Use frame 35 to answer the following question on the response sheet. The blank may require more than one number.

_____7. DPST toggle switches are identified by what number(s) in frame 35?

_____8. DPDT toggle switches are identified by what number(s) in frame 35?

Answers to Frame 9: T 1. T 2. ____3. ____4. ____5.
T 6. 2,10 7. 12 8.

Frame 10

We have talked about symbols a number of times in the past frames. Let us see what you have learned about them. All of the items listed below are toggle switches.

DO NOT MARK IN THIS TEXT

Match the switches to their symbols. Write the letter representing the symbol in the proper blank on the response sheet.

____1. SPDT, 2-position

____2. DPST, 2-position.

____3. SPST, 2-position.

____4. SPST, 2-position, spring loaded to OFF.

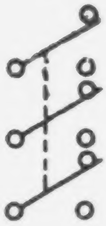
____5. SPDT, 3-position, 1 position spring loaded to OFF.

____6. TPDT, 2-position.

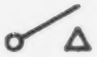
____7. TPDT, 3-position.

____8. 4PDT, 3-position.

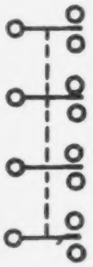
A.



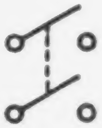
B.



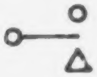
C.



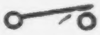
D.



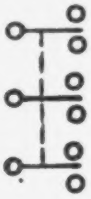
E.



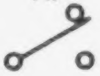
F.



G.



H.



Answers to Frame 10: ___h___1. ___d___2. ___f___3. ___b___4. ___e___5.

___a___6. ___g___7. ___c___8.

Frame 11

Using the list of switches below, locate the switches in frame 35 and enter the switch number in the blanks provided on the response sheet. Again we are talking about toggle switches only. It is possible that more than one number can go in a blank.

DO NOT MARK IN THIS TEXT

_____a. SPDT, 2-position.

_____b. 4PDT, 3-position, 1 position spring loaded to OFF.

_____c. DPST, 2-position.

_____d. SPST, 2-position, spring loaded to OFF.

_____e. 4PDT, 3-position.

_____f. DPDT, 3-position.

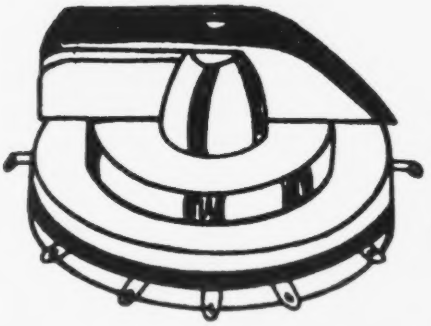
_____g. SPDT, 3-position, 1 position spring loaded to OFF.

Answers to Frame 11: 19 a. 17 b. 2,10 c. 3 d. 18 e.

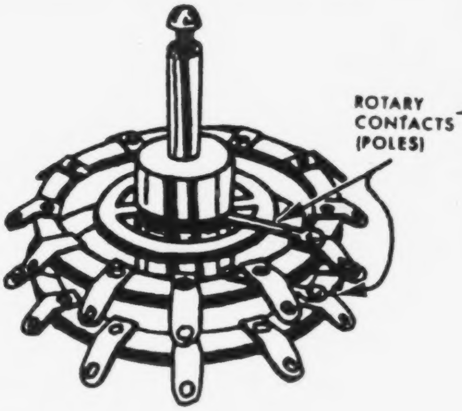
12 f. 11 g.

Frame 12

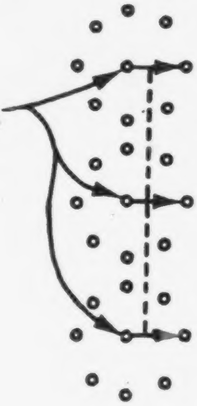
Another type of manual switch is the rotary selector switch as shown below. When the knob of the switch is turned, the switch opens one circuit and closes another. Sometimes there are a number of wafers stacked, one on top of the other. When the knob is in any one position, it will complete a circuit in that position for each wafer. This type switch is used as the function switch on multimeters. Study the rotary switch stack type in your classroom display board #9.



1 WAFER
A



2 WAFERS
B



3 WAFERS
C

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on the response sheet.

_____1. The dashed line in the schematic symbol, figure C, means that all the poles are mechanically linked together.

_____2. The schematic symbol, figure C, shows that the switch is a triple-pole (TP) 8-position rotary selector switch.

_____3. The drawings above are all of the same switch.

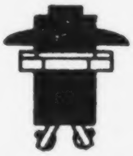
Use frame 35 to answer the following questions on the response sheet. The blank may require more than one number.

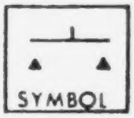
_____4. Rotary selector switches are identified by what number(s) in frame 35?

Answers to Frame 12: __T__1. __T__2. _____3. __7__4.

Frame 13

One more type of manual switch used on the aircraft is shown below. It is known as a push button switch. This type is used in your home to ring the door bell. On the aircraft it can be used as a microphone button. When the pilot wants to talk over the radio he simply pushes the microphone button.





DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on the response sheet.

_____1. To complete the circuit, the button is pressed.

_____2. When the button is released, the circuit is broken.

_____3. This would be a good switch to use in a lighting circuit.

_____4. The triangles in the symbol represent momentary contacts which means the switch is spring loaded to OFF.

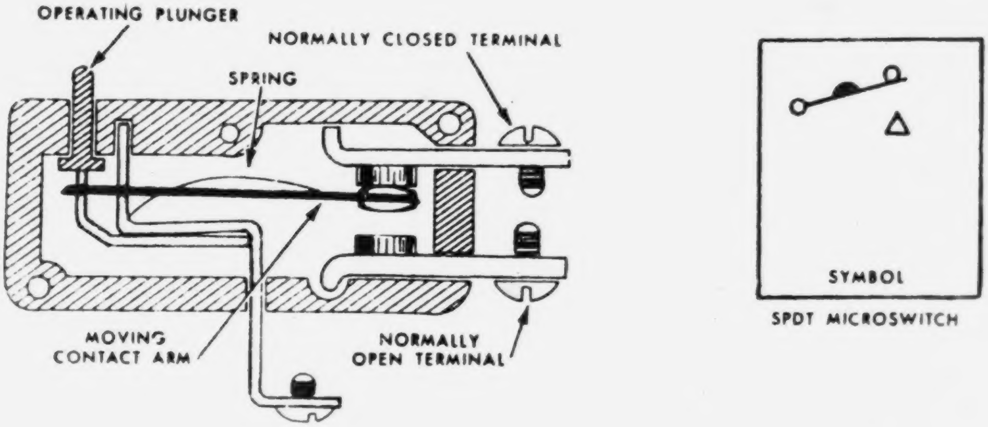
Use frame 25 to answer the following question on the response sheet. The blank may require more than one number.

_____5. Push button switches are identified by what number(s) in frame 35?

Answers to Frame 13: _T_ 1. _T_ 2. ____ 3. _T_ 4. _15_ 5.

Frame 14

Mechanical switches will be the next group of switches that we will study. The word mechanical means that they are operated by some mechanical device. These switches are shown as normally open (NO) or normally closed (NC) depending on the position to which they are spring loaded. They will always be spring loaded to one of these positions, and will have no center OFF position. This kind of switch is called a microswitch or limit switch.



SPDT MICROSWITCH

The operating plunger in some way will always be hooked to some kind of spring as shown in the drawing above. When some kind of mechanical thing pushes the plunger down, the switch will change positions. The switch can be wired to either the NO or NC. Each of the positions can complete a circuit, or only one set of contacts may be used. It all depends on where the switch is used.

DO NOT MARK IN THIS TEXT

Mark the correct answer for each of the following questions on the response sheet.

____ 1. The switch shown above is a

a. NC microswitch.
b. NO microswitch.

____ 2. The switch shown above is a

a. two-position switch.
b. three-position switch.

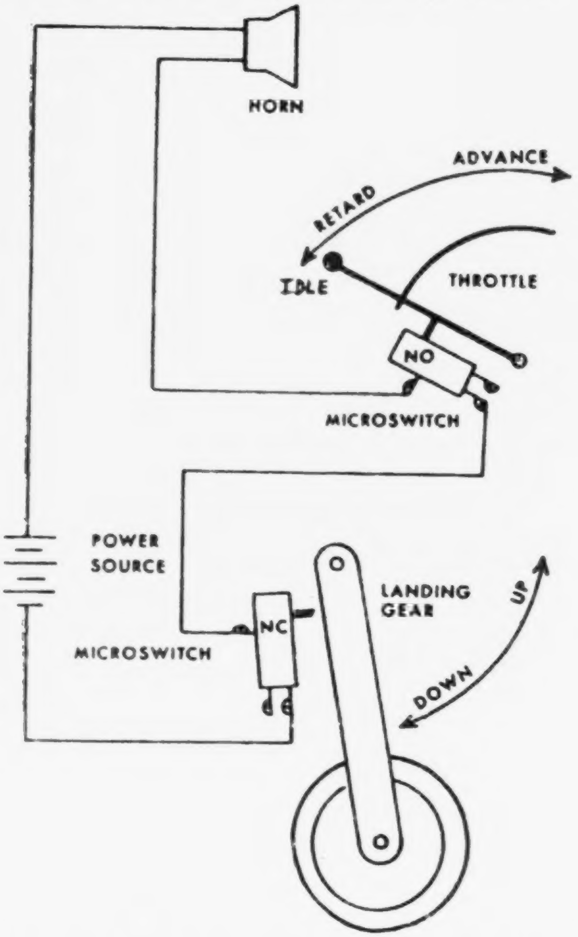
____ 3. In the above switch the moving contact arm could be called the

a. pole.
b. position.

Answers to Frame 14: __a__1. __a__2. __a__3.

Frame 15

Let us see how two switches like the one in frame 14 can be used in a circuit. One of the switches is NO and the other is NC. In the schematic, the throttle microswitch is NO and the gear switch is NC. This means if the throttle were pulled back to idle, the mechanical hook up would press the plunger in the switch and close the circuit. If the gear is down and locked, the plunger would be pressed to open the circuit. With the condition shown the warning horn would sound, warning the pilot that his gear is not down and locked. Normally, the throttle is only retarded when the pilot is attempting to land.


HORN
ADVANCE
RETARD
IDLE
THROTTLE
NO
MICROSWITCH
POWER SOURCE
LANDING GEAR
UP
NC
MICROSWITCH
DOWN

Mark the following true statements with a "T" on the response sheet.

_____1. If the throttle is retarded and the gear is down and locked, the warning horn will sound.

_____2. When the gear comes down, the gear switch will OPEN.

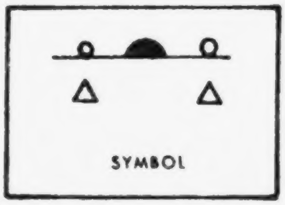
_____3. When the throttle is retarded, the throttle microswitch will OPEN.

_____4. The purpose of the above circuit is to warn the pilot if his gear is not down when he is attempting to land.

Answers to Frame 15: _____1. __T__2. _____3. __T__4.

Frame 16

The symbols for microswitches can be drawn several ways, but they are all easy to identify by the little hump drawn over the pole. Another symbol for a microswitch is drawn below.



DO NOT MARK IN THIS TEXT

Use frame 35 to answer the following question on the response sheet. The blank may require more than one number.

_____1. Microswitches are identified by what number(s) in frame 35?

Mark the following true statements with a "T" on the response sheet.

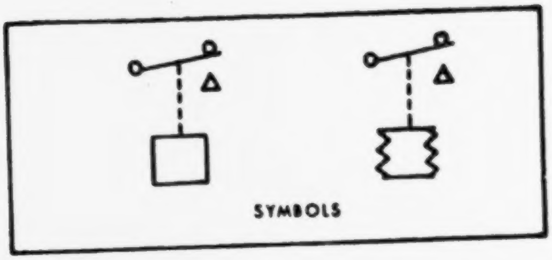
_____2. Microswitches can be identified as SPDT, 2-position, etc.

_____3. The switch identified by the symbol above would be a SPDT, 2-position microswitch.

Answers to Frame 16: 4, 14 1. T 2. T 3.

Frame 17

Mechanical switches can also be operated by other means. In hydraulic or pneumatic systems, we need something to tell us when the pressure is too high or too low. Because of this, we have a need for pressure switches. The symbol for a pressure switch can be drawn two ways. Examples are shown below.



Both of the symbols above represent pressure switches which would move from normally CLOSED to momentary ON position when the pressure builds up to a given amount. REMEMBER: Whenever you see dashed lines under a switch, the lines represent only mechanical linkage (connection), not circuit (electrical) connections.

DO NOT MARK IN THIS TEXT

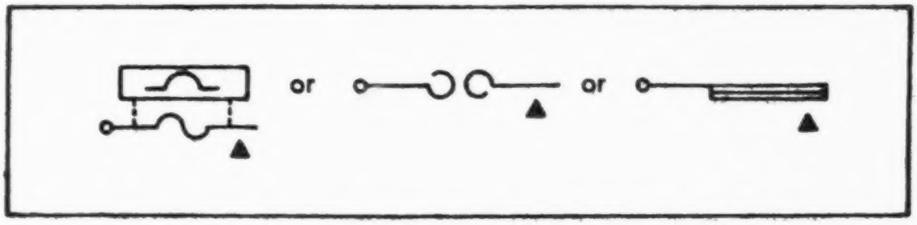
Use frame 35 to answer the following question on the response sheet. The blank may require more than one number.

_____1. Pressure switches are identified by what number(s) in frame 35?

Answer to Frame 17: 16 1.

Frame 18

Another type of mechanical switch is operated by heat. It is often used when time delays are needed in the circuit. It takes a little time for the switch to warm up and then close. Several symbols for the heat or thermal switch are shown below.



When the element (not shown in the symbols) is heated, the metals expand to touch the contact, completing the circuit. Other uses for thermal switches are as warning switches and temperature sensing devices.

DO NOT MARK IN THIS TEXT

Use frame 35 to answer the following question on the response sheet. The blank may require more than one number.

_____1. Thermal switches are identified by what number(s) in frame 35?

518

Answer to Frame 18: ___5___1.

Frame 19

You have now covered most of the control devices in frame 35. Let us see what you have learned.

DO NOT MARK IN THIS TEXT

Match the switches to their symbols. Write the letter representing the symbol in the proper blank on the response sheet.

_____1. SPST pressure switch.

_____2. SP rotary selector switch.

_____3. SPDT microswitch.

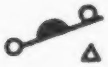
_____4. DPDT toggle switch.

_____5. SPDT push button switch.

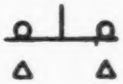
_____6. DP rotary selector switch.

_____7. Thermal switch.

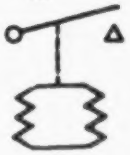
a.



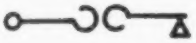
b.



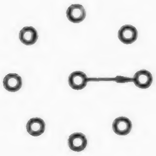
c.



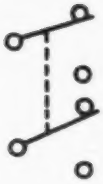
d.



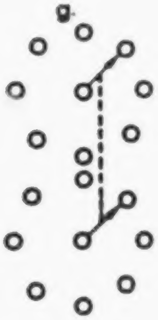
e.



f.



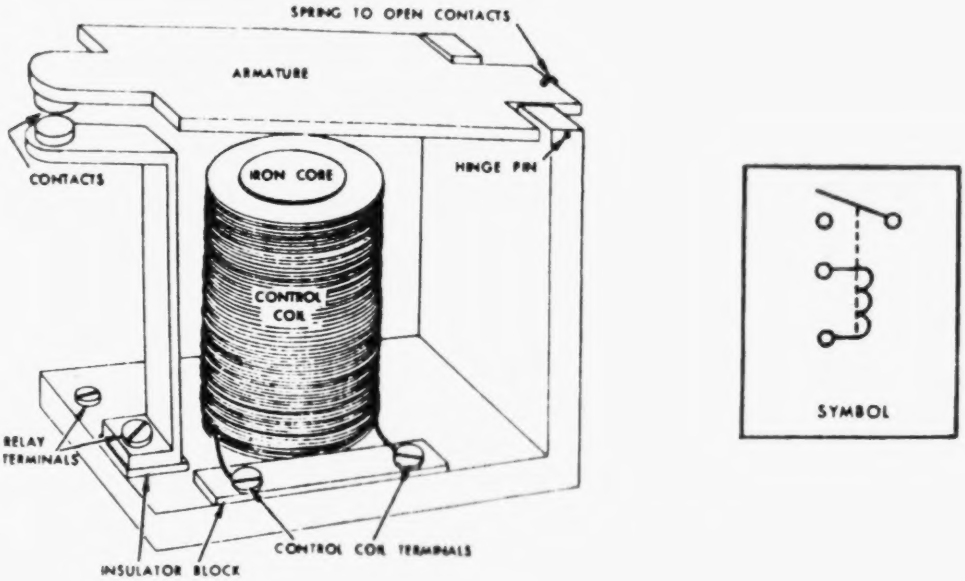
g.



Answers to Frame 19: c 1. e 2. a 3. f 4. b 5.
g 6. d 7.

Frame 20

This brings us to the third class of switches; the magnetic type. These switches are better known as relays and can be placed into two different types, fixed core and movable core. See display #9 in your classroom for relay displays.


SPRING TO OPEN CONTACTS
ARMATURE
CONTACTS
IRON CORE
HINGE PIN
CONTROL COIL
RELAY TERMINALS
INSULATOR BLOCK
CONTROL COIL TERMINALS
SYMBOL

The Relay is a Switch
Operated by an Electromagnet.

The relay shown on this page has a fixed core. When current passes through the coil surrounding the core, it produces an electromagnetic field which attracts the iron armature and pulls it down against spring tension. This closes the contacts to complete the circuit. When there is no current flow in the coil, the spring tension opens the contacts.

DO NOT MARK IN THIS TEXT

Mark the correct answer for each of the following questions on the response sheet.

_____1. The relay shown is a

a. DPST relay.
b. SPST relay.

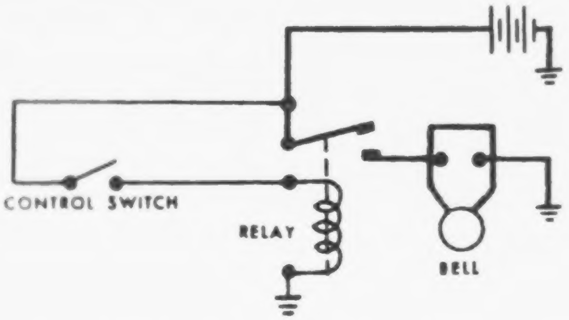
_____2. A relay is actually a

a. switching device.
b. safety device.

Answers to Frame 20: b 1. a 2.

Frame 21

Relays are used to open or close circuits by remote control. Note that there are two distinct circuits. In the diagram below, both circuits use the same battery power source. The control circuit consists of the switch and the relay coil. The controlled circuit consists of the relay contacts and the bell which are in the circuit with the heavy dark lines.



The relay can be placed in the circuit close to the unit it controls. This eliminates a great amount of heavy wiring, thereby reducing aircraft weight. The relay is then controlled by smaller wires which can be operated from any place inside the aircraft.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on the response sheet.

_____1. The circuit which causes the relay to operate could be called the control circuit.

_____2. The relay contacts above are in the control circuit.

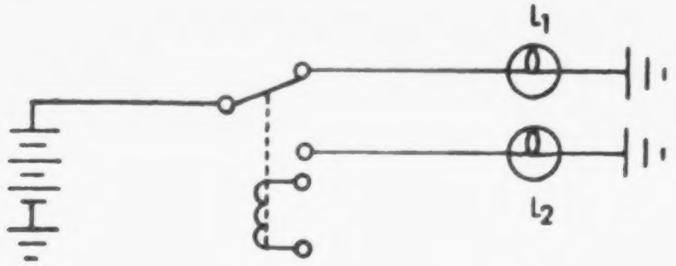
_____3. The schematic above shows the relay coil mechanically linked to the relay armature.

_____4. The bell circuit could be called the load circuit.

Answers to Frame 21: _T_ 1. ____ 2. _T_ 3. _T_ 4.

Frame 22

So far we have avoided saying that a relay is either open or closed. The reason for this is explained in the following sentences. Let us take a look at another symbol for a relay wired in a simple circuit.



You can see that the relay above completes a circuit in either position. So, which position would be the CLOSED position? The answer is, both positions are CLOSED. Therefore it is far better to speak of a relay as being either energized or deenergized. Energized means that current is flowing through the coil pulling the contacts toward the coil. Relays are always drawn deenergized unless otherwise stated.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on the response sheet.

_____1. The relay shown is a SPST relay.

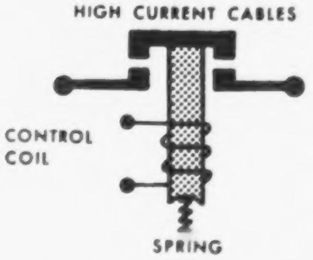
_____2. When the relay is deenergized, the lamp #1 will glow.

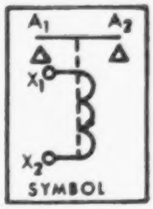
_____3. Both lamps can operate at the same time.

Answers to Frame 22: _____1. __T__2. _____3.

Frame 23

There are probably just as many types of relays as there are toggle switches. Some relays require large amounts of current to flow through the contacts. You might say they are heavy duty relays. Their symbols are drawn as in the diagram on this page.





The coil hook ups are usually labeled X1 and X2, while the contacts are labeled A1 and A2, B1 and B2, etc. Notice that triangles are used to show memomentary contacts the same as they do in toggle switches. These type of relays are often called solenoid relays and have movable cores. The soft iron core is hooked to the bar or bars at the top. When current flows through the coil, the electromagnet will tend to center the iron core into the hollow center of the coil.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on the response sheet.

_____1. Solenoid relays are used as heavy duty relays.

_____2. Solenoid relays have fixed cores.

_____3. If you see the letters X_1 and X_2 on the terminals of a relay, you will know that these are the coil connections.

Use frame 35 to answer the following question on the response sheet. The blank may require more than one number.

_____4. Relays are identified by what number(s) in frame 35?

Answers to Frame 23: _T_ 1. ____ 2. _T_ 3. _13_ 4.

Frame 24

DO NOT MARK IN THIS TEXT

Match the list of relays below to their symbols.

Write the letter corresponding to the proper symbol in the blanks provided on the response sheet.

_____1. SPDT fixed core relay.

_____2. 4PDT fixed core relay.

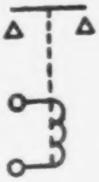
_____3. TPDT fixed core relay.

_____4. SPST solenoid relay.

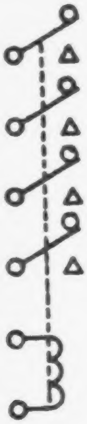
_____5. SPST fixed core relay.

_____6. 4PST solenoid relay.

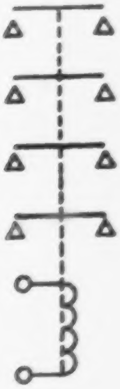
a.



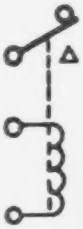
b.



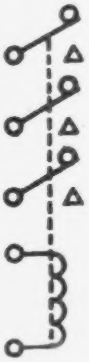
c.



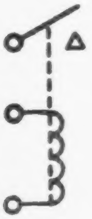
d.



e.



f.



Answers to Frame 24: d 1. b 2. e 3. a 4. f 5. c 6.

Frame 25

Use the list of relays below, and locate the relay in frame 36 of this text. Write the number of the relay in the blanks provided on the response sheet. A blank may require more than one number.

DO NOT MARK IN THIS TEXT

_____a. TPST relay.

_____b. 4PDT relay.

_____c. SPST relay.

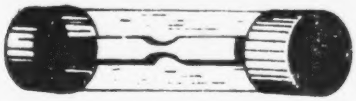
_____d. SPDT relay.

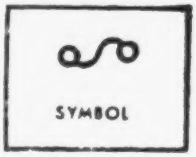
_____e. TPDT relay.

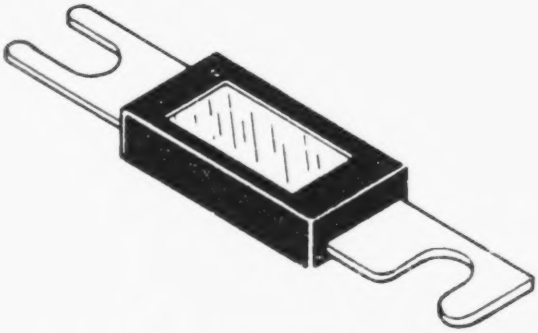
Answers to Frame 25: 4 a. 8 b. 1, 2, 5, 14 c. 7 d. 3, 6 e.

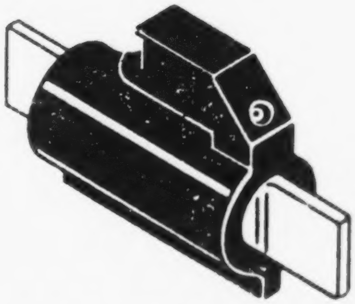
Frame 26

Now we are ready to discuss protective devices. The purpose of these devices is to protect electrical circuits from excessive overload or circuit damage. An overload means that too much current is flowing in the circuit. This condition can be caused by a short circuit, or trying to operate too many units on one circuit. Overloaded circuits cause the wire to overheat, and possibly burst into flames. Protective devices are known as fuses or circuit breakers. Let us talk about fuses first. Here are a few examples.









The fuses elements are made to melt at a much lower temperature than the wire in the circuit it is protecting. In case of an overload, the fuse element melts to open the circuit.

DO NOT MARK IN THIS TEXT

Mark the following true statements with a "T" on the response sheet.

_____1. A fuse rated at 5 amps would blow (burn out) if 6 amps were flowing in the circuit.

_____2. A protective device should be used in every circuit.

Use frame 36 to answer the following question on the response sheet. The blank may require more than one number.

_____3. Fuses are identified by what number(s) in frame 36?

Answers to Frame 26: T 1. T 2. 11, 12, 13 3.

Frame 27

Other types of fuses will allow a power overload for a short period of time before blowing. These type fuses are usually referred to as "slow blow" fuses. They are needed in electric motor circuits because motors require higher current for starting than they need for continuous running. If for some reason this higher current flow should go on past the starting stage, the fuse would blow, protecting the circuit. These fuses are perfectly safe since it takes a little time for the wires to heat up. If we put in exactly the right size fuse to protect the circuit wiring for a running motor, it would blow every time the motor started.

DO NOT MARK IN THIS TEXT

Mark the correct answer for each of the following questions on the response sheet.

_____1. High starting current would probably blow an ordinary

a. switch.
b. fuse.

_____2. "Slow blow" fuses will allow higher than rated current flow

a. temporarily.
b. indefinitely.

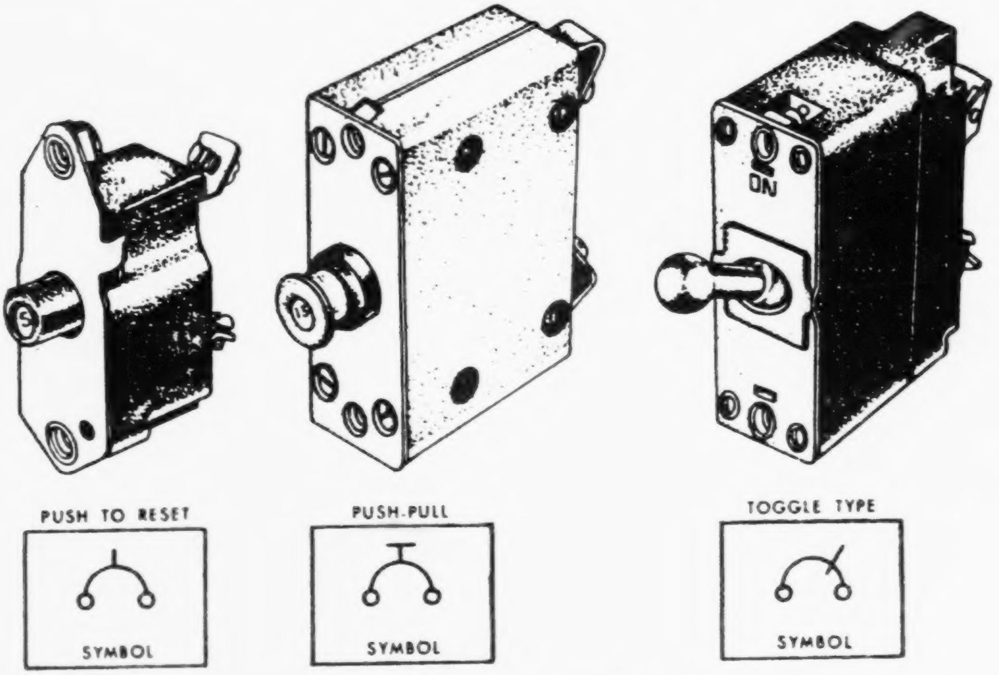
_____3. A blown 10 amp fuse was replaced in a 10 amp circuit. There would be a possibility of fire without the fuse ever blowing if it was replaced by a

a. 30 amp fuse.
b. 5 amp fuse.

Answers to Frame 27: b 1. a 2. a 3.

Frame 28

Another type of protective device is known as a circuit breaker. Three types of circuit breakers are shown below along with the symbol for each. Circuit breakers serve the same function as fuses, that is, to protect circuits in the event of an overload.



The push-pull and the toggle-type circuit breakers can be used to open a circuit manually, the same as you would do with a switch. All of these will work automatically to open the circuit in the event of an overload.

DO NOT MARK IN THIS TEXT

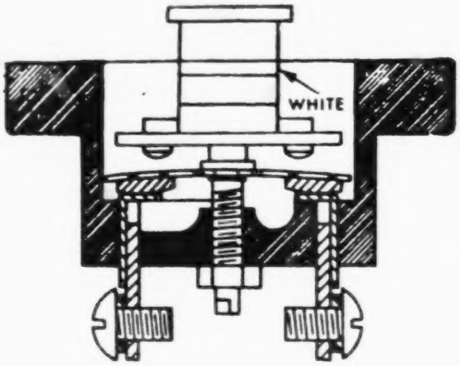
Use frame 36 to answer the following question on the response sheet. The blank may require more than one number.

_____1. Circuit breakers are identified by what number(s) in frame 36?

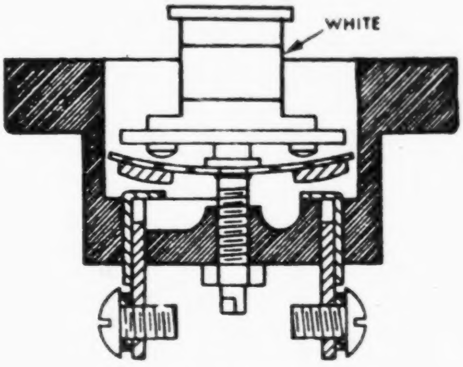
Answers to Frame 28: 9, 10 1.

Frame 29

Circuit breakers operate on the thermal effect of current. This means that wires and electrical components are heated by the current that flows through them. If too much current flows through a circuit breaker, the heat created by the current causes the circuit breaker to trip or "pop." You can tell at a glance when a push button or push-pull circuit breaker is tripped because of a white band around the button. When the button is pushed in, you cannot see the white band. When the cirjuit breaker is tripped, the white band is exposed. You can also tell when the toggle type circuit breaker is tripped, because it will be in the OFF position.



BREAKER CLOSED
ON NORMAL LOAD



CLICK! IT OPENS!
ON OVERLOAD

Mark the following true statements with a "T" on the response sheet.

_____1. The thermal effect which causes a circuit breaker to trip is caused by the applied voltage.

_____2. A circuit breaker is a device which prevents damage to circuit components.

_____3. You can tell when a circuit breaker is pushed in, because you can see the white band.

Answers to Frame 29: _____1. __T__2. _____3.

Frame 30

Fuses and circuit breakers should never be bypassed by putting a penny behind a fuse or wrapping a fuse with tinfoil. If a fuse blows or a circuit breaker "pop," their is usually a good reason for this to happen. If you bypass the protective device, a serious fire could result. NEVER BYPASS A PROTECTIVE DEVICE. Neither should you replace a protective device with one that has a larger rating than is called for in the circuit.

Mark the following true statements with a "T" on the response sheet.

_____1. A penny placed behind a fuse would cause the circuit protection to be bypassed.

_____2. Many fires are caused on aircraft because of the lack of circuit protection.

_____3. Bypassing the circuit protective device would be the same as having no protection at all.

Answers to Frame 30: _T_ 1. ____ 2. _T_ 3.

Frame 31

All control and protective devices are rated by current and voltage. Some devices have a data plate and others have the rating stamped on the side of the case. Always use devices with proper ratings in any circuit.

DO NOT MARK IN THIS TEXT

Mark the correct answer for each of the following questions on the response sheet.

____ 1. Control and protective devices have two things in common. They are all rated in

a. current only.
b. voltage only.
c. current and voltage.

____ 2. Ratings can usually be found some place on the control or protective device.

a. True
b. False

____ 3. You should pay strict attention to the control and protective devices

a. manufacture title.
b. ratings.

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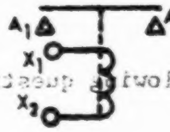
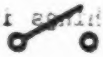
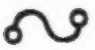
Answers to Frame 31: 1. c 2. a 3. b

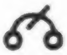
Frame 32

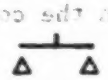
Now let's see what you have learned about control and protective devices. Match the terms on the right with the symbols on the left. Write the letter corresponding to the appropriate device in the blanks provided on the response sheet.

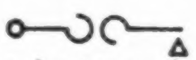
______ 1. 

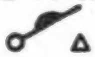
______ 2. 

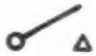
______ 3. 

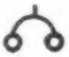
______ 4. 

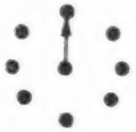
______ 5. 

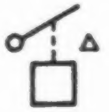
______ 6. 

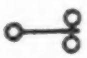
______ 7. 

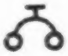
______ 8. 

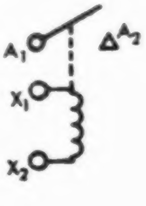
______ 9. 

______ 10. 

______ 11. 

______ 12. 

______ 13. 

______ 14. 

a. "Momentary on" switch
b. Pushbutton switch
c. Circuit breaker (push-pull)
d. SPST relay (solenoid-type)
e. Thermal switch
f. SPDT switch (toggle)
g. Circuit breaker (push-to-reset)
h. Pressure switch
i. Rotary 8-position switch
j. Microswitch (limit switch)
k. SPST switch (toggle)
l. SPST relay (fixed-core type)
m. Circuit breaker (toggle-type)
n. Fuse

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Answers to Frame 32: _d_ 1. _k_ 2. _n_ 3. _m_ 4. _b_ 5.
_e_ 6. _j_ 7. _a_ 8. _g_ 9. _i_ 10.
_h_ 11. _f_ 12. _c_ 13. _l_ 14.

Frame 33

Using the list of control and protective devices below, find these items to frames 35 and 36, and list their corresponding numbers in the blanks provided on the response sheet. You may have to use more than one number in a blank. It is NOT important that you list which frame the item is on, as long as you have the correct number in the proper blank.

_____a. SPST "momentary ON" switch (toggle)

_____b. Push-button switch

_____c. Circuit breaker (push-pull)

_____d. SPST relay (solenoid-type)

_____e. Thermal switch

_____f. SPDT switch (toggle)

_____g. DPDT switch (toggle)

_____h. Pressure switch

_____i. Rotary switch

_____j. Microswitch (limit switch)

_____k. SPST switch (toggle)

_____l. SPDT relay (fixed-core-type)

_____m. Circuit breaker (toggle-type)

_____n. Fuse

Answers to Frame 33: 3 a. 15 b. 9 c. 14 d. 5 e.

19, 11 f. 12 g. 16 h. 7 i.

4, 14 j. 1, 3, 6 k. 7 l. 10 m.

11, 12, 13 n.

Frame 34

Which of the following ratings are common to fuses, circuit breakers, and switches? Write the letter which identifies your answer on the response sheet.

a. Current, voltage and pressure.

b. Current, voltage, and blow characteristics.

c. Current, voltage and temperature.

d. Current and voltage.

Answer to Frame 34: d

Frame 35

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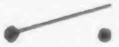

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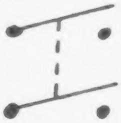

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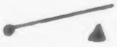

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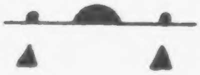

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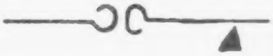

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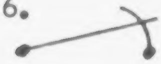

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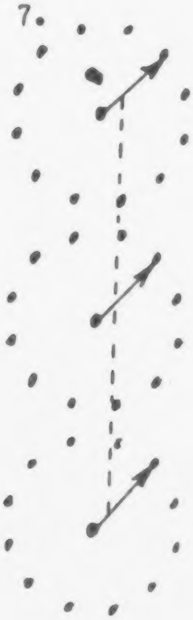

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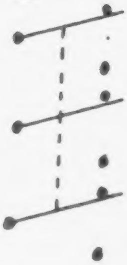

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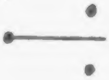

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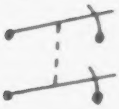

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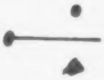

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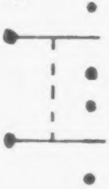

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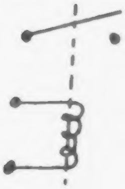

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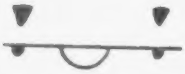

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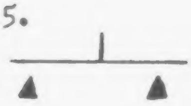

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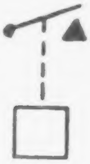

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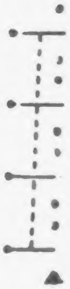

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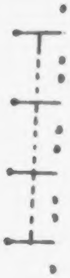

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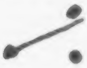

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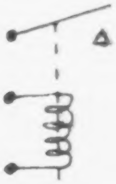

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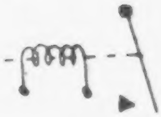

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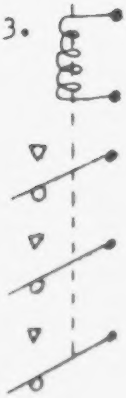

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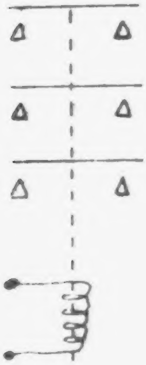

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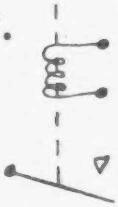

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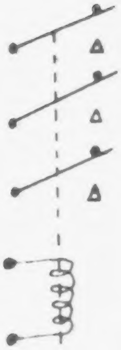

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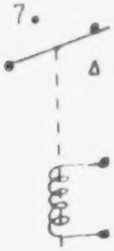

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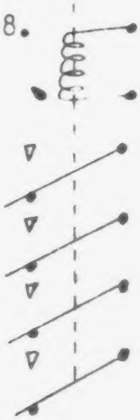

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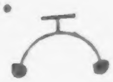

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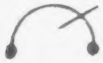

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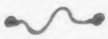

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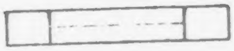

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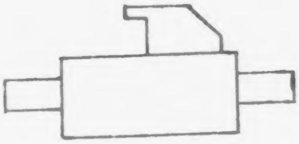

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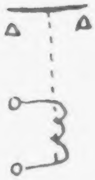


PROGRAMMED TEXT
C3ABR42331-PT-112

Technical Training

Aircraft Environmental Systems Mechanic

USE OF TEST EQUIPMENT
(PSM-37 MULTIMETER)

9 July 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

OBJECTIVE

Given a power bench, a voltage, current, and resistance readings test board, and a PSM-37 multimeter, measure to the nearest graduation on the meter's scale four sets of electrical values. A minimum of 9 out of 10 of the DC voltage, AC voltage, and DC current sets must be correct. A minimum of 4 out of 5 of the resistance sets must be correct.

INSTRUCTIONS

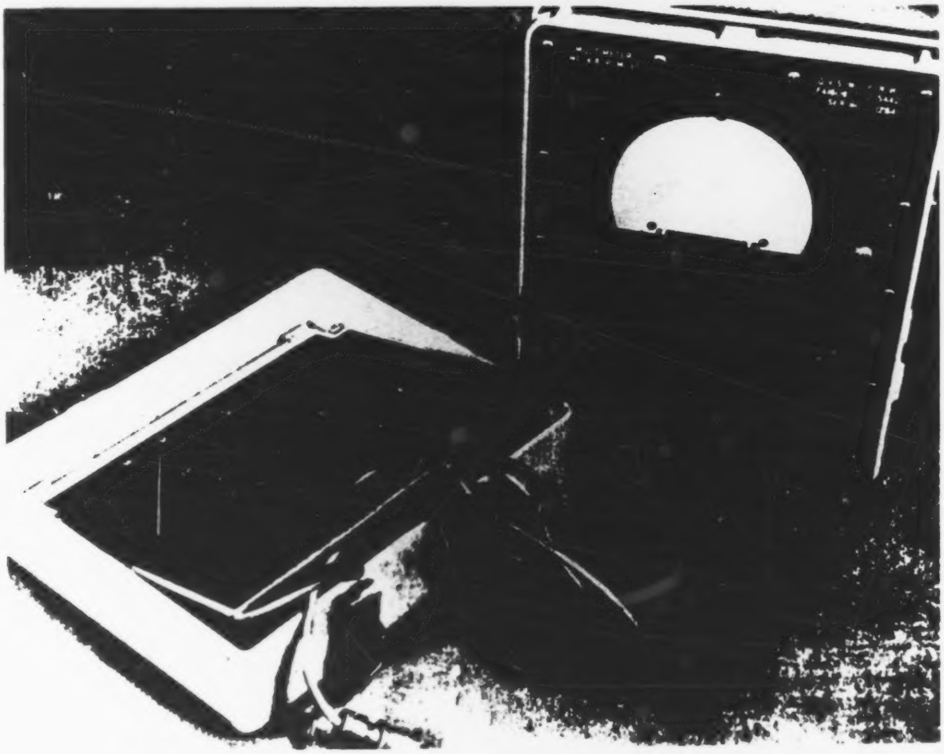
This Programmed Text presents information in small steps called "frames". Carefully study the material and respond when required. Check your responses with the answers given on the next page. If you don't understand the material ask your instructor for assistance.

INTRODUCTION

In the inspection, maintenance, and operation of Aircraft Environmental Systems you will sometimes run into problems with electrical circuits. To find the cause of the problems you will be required to measure:

1. The amount of current flowing through a circuit.
2. The voltage at various points throughout the circuit.
3. Circuit resistance.

The multimeter is a multipurpose instrument that can measure AC/DC voltages, resistance, and AC/DC current flow.



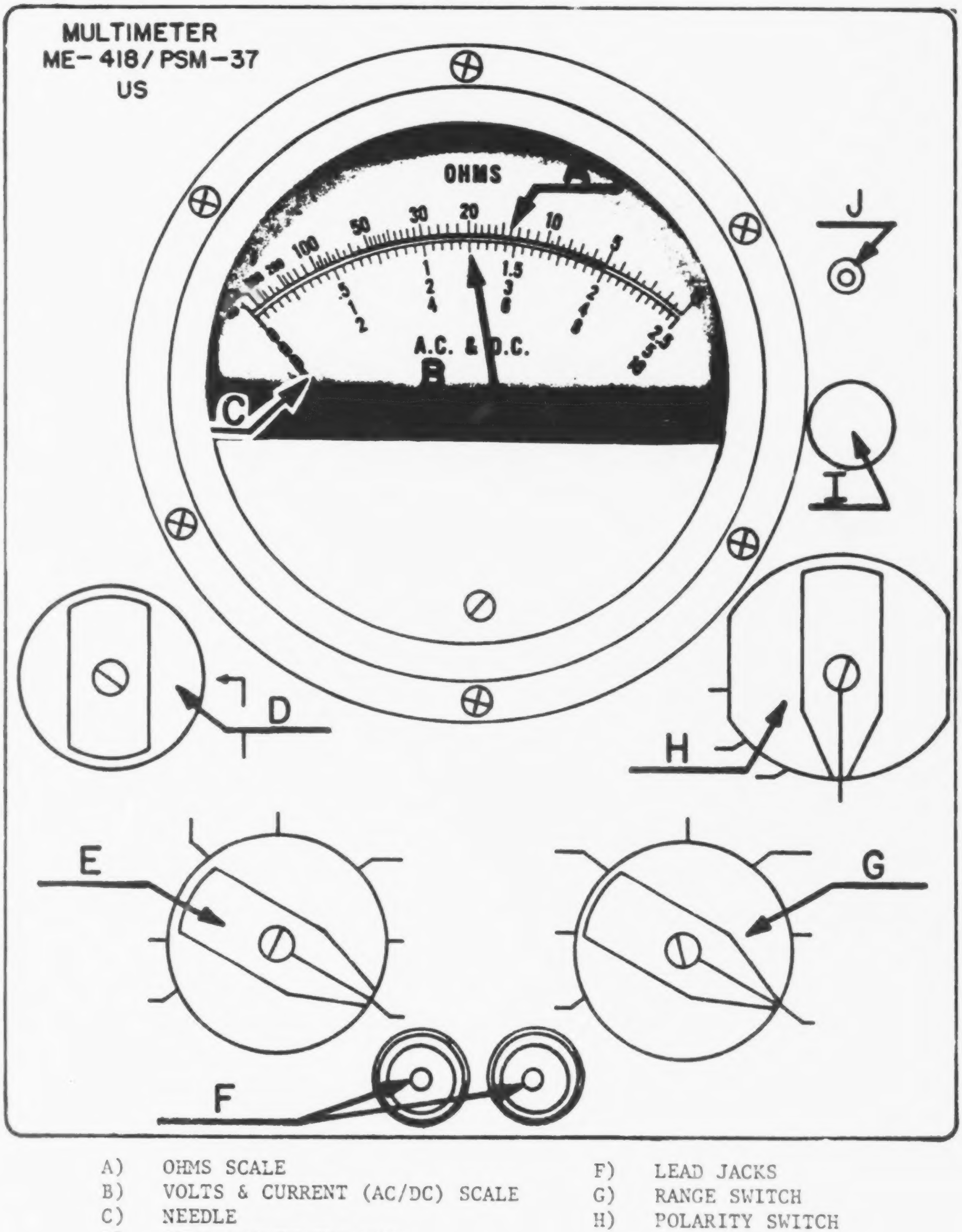
Supersedes ST C3ABR42331-PT-112, 19 November 1982.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

538

Frame 1

Below is an illustration of the PSM-37 multimeter. Familiarize yourself with the location of its parts.

NO RESPONSE REQUIRED


MULTIMETER
ME-418/PSM-37
US
OHMS
100
50
30
20
10
5
.5
1
2
1
2
4
1.5
3
6
2
4
8
2.5
A.C. & D.C.
A
B
C
D
E
F
G
H
I
J

A) OHMS SCALE
B) VOLTS & CURRENT (AC/DC) SCALE
C) NEEDLE
D) OHMS ADJUSTMENT KNOB
E) FUNCTION SWITCH
F) LEAD JACKS
G) RANGE SWITCH
H) POLARITY SWITCH
I) RESET BUTTON
J) OVERLOAD INDICATOR

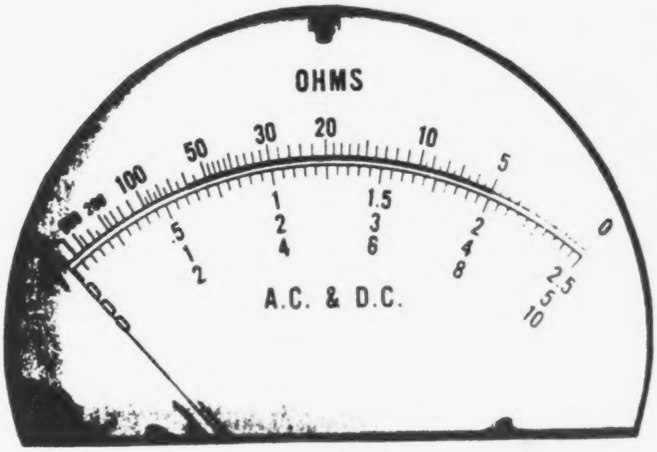
Frame 2

The meter face shows the values that you are measuring. It is made up of two scales, OHMS and AC and DC.

The green OHMS scale is used when you make a resistance test. It is read from right to left (0 - ∞).

The black AC & DC scale is used when you make a voltage or current test of circuits. The values of the scales will be volts when measuring voltage and milliamperes (MA) when you test for current.

The meter needle (pointer) points to the value of volts, milliamperes or ohms being measured.

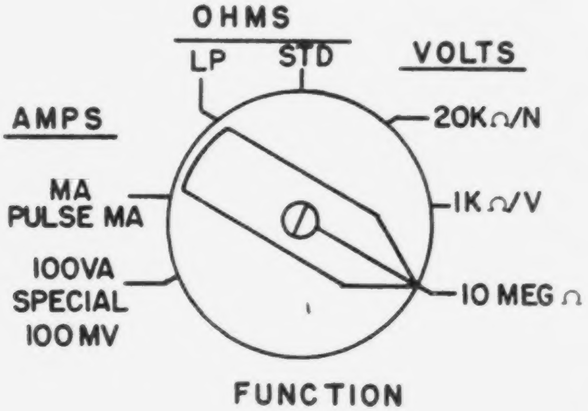


Match the statement or function in Column B with the names to which they relate to in Column A.

Column A	Column B
_____ 1. OHMS scale	a. Black scale and read left to right.
_____ 2. AC & DC scale	b. Moves to indicate the value being measured.
_____ 3. Needle	c. Ranges from zero (0) to infinity (∞).

Answers to Frame 1: No Response Required

The FUNCTION switch can be seen in the lower left on the meter front. It is used to set the meter up to test for AMPS, OHMS, or VOLTS. The ones that you will have to use are the "MA" position for current checks, the 1KΩ/V for voltage checks, and "LP" and "STD" for resistance checks. The "LP" position on ohms has a low power output for use when testing small values of resistance (0 to 60 Ω). The "STD" is used for all other ohms checks.


OHMS
LP
STD
VOLTS
AMPS
20KΩ/N
MA
PULSE MA
1KΩ/V
100VA
SPECIAL
100MV
10 MEG Ω
FUNCTION

Place a checkmark (✓) beside each true statement.

_____ 1. To set the meter for measuring voltage, you would turn the function switch to 1KΩ/V voltage setting.

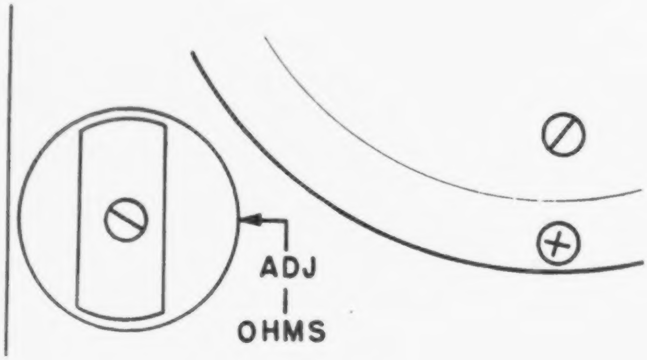
_____ 2. The "STD" position of the function switch is for measuring low powered components.

Answers to Frame 2: 1. c, 2. a, 3. b.

Frame 4

The OHMS ADJUST knob is found at the center and to the left of the meter front and is marked ADJ. It is used to compensate for the aging of the batteries that are in the meter. It is turned to make the needle line up on the "0" on the ohms scale, before you make a resistance check.

NO RESPONSE REQUIRED.

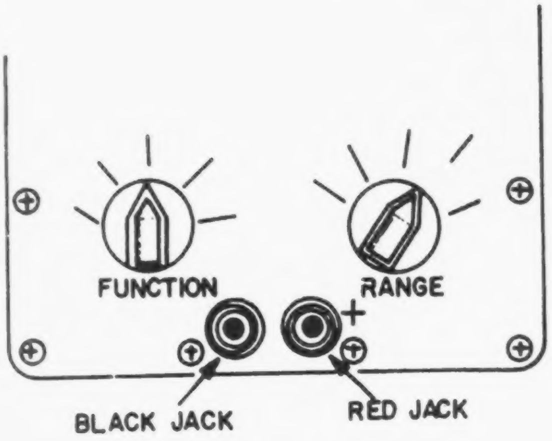


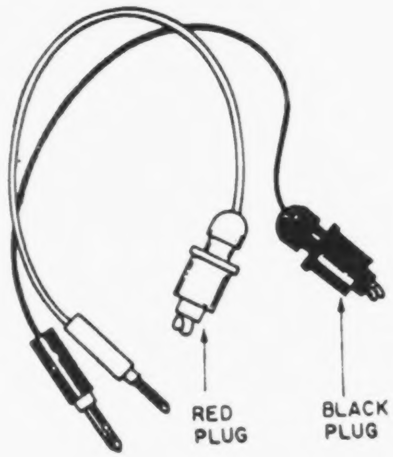
Answers to Frame 3: __✓__ 1. _____ 2.

Frame 5

The test jacks are found at the bottom center of the meter front. The red one is the positive jack and is marked with a "+". The black jack is negative and is not marked. The two jacks give a connection point for the meter leads. There are two meter leads; one red and one black. The red lead will always be placed in the positive side of the circuit and the black in the negative. If you reverse the leads, the meter may be damaged when it is connected to a live circuit (one that has power on). Refer to the diagram below.

Note: Place your meter leads in the test jacks of your meter at this time (the leads are normally stored in the meter lid).





Complete the following statement(s) by choosing the correct word OR words and record.

1. The red lead is ______________ (negative-positive) and is connected to the ______________ (red-black) meter jack. The ______________ (red-black) negative lead is connected to the ______________ (red-black) meter jack.

Answer to Frame 4: No Response Required

Frame 6

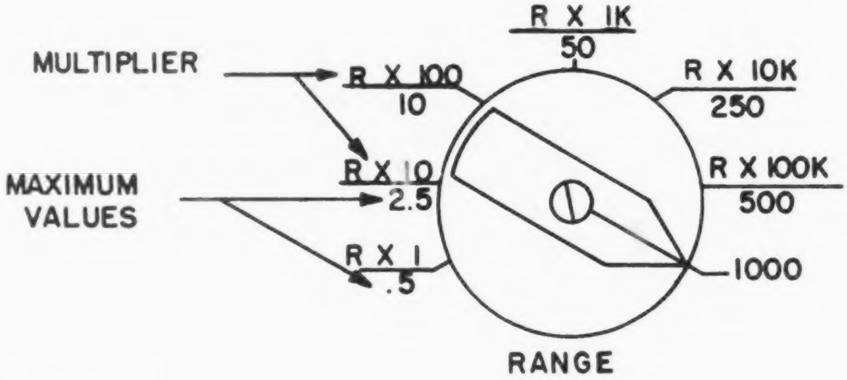
The RANGE switch is found in the lower right corner of the meter front and is marked RANGE.

The range switch is used to set the maximum values of voltage and current to be measured or the multiplier for the resistance checks. The maximum range settings for voltage and amps are those numbers below the line. The multiplier is the R X numbers above the line. The position of the RANGE switch relates one of three things to the operator:

1. The maximum voltage that the meter can measure at that particular range setting. For example: When set on 10, the meter's highest voltage reading is 10 volts. On a switch setting of 1,000, the highest voltage value the meter can read is 1,000 volts. When reading voltage, set the function switch to 1KΩ/V.

2. The maximum current that the meter can measure at that particular range setting. The RANGE switch is used in the same manner as when using it for voltage. When reading current, set the FUNCTION switch to the MA/pulse MA position.

3. The multiplier of the ohmic (resistance) value that the meter is reading. Set the FUNCTION switch to the OHMS-STD position and the range switch to R x 1K. Multiply the meter reading by 1,000 to get the correct resistance value. The reason you multiply by 1,000 is that K means Kilo or 1,000. 50x1K would equal 50,000.



Place a "T" in the space provided beside each true statement.

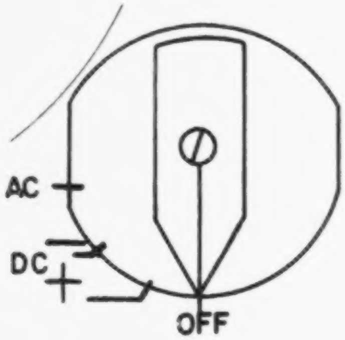
_____ 1. The range switch means the maximum voltage the meter will measure on the OHMS function.

_____ 2. While the PSM-37 is set to AMPS - MA, the range switch tells the operator the maximum current the meter is capable of measuring at that setting.

_____ 3. With the RANGE switch in the R X 10K/250 setting, the operator would multiply the OHMS scale readings by 10,000.

Answers to Frame 5: 1. positive, red, black, black

Located on the right side of the meter just above the range switch is the POLARITY switch. The POLARITY switch turns the multimeter on and off, and sets the meter to test DC+, DC-, or AC. The "+" and "-" signs mean the POLARITY that must be applied to the red test lead when you make DC measurements so that the meter pointer will move up scale to the right. If the pointer moves to the left, just change the POLARITY switch to the other DC setting or reverse the test leads in the circuit. When you make OHMS checks, the + or - will mean the output polarity of the red test lead. The shape of the POLARITY switch knob will not allow the cover for the meter to be put on unless the switch is in the off position.



Complete the following statements by placing the correct word(s) in the blank spaces.

1. When a negative voltage is applied to the red lead, the polarity switch must be turned to the ____________________ position.

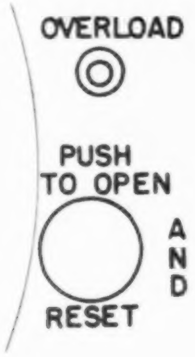
2. The meter POLARITY switch would be turned to ______________ position when measuring alternating current.

3. If the meter needle moves to the left of the "0" on AC & DC scale, the ________________ switch must be turned to the opposite DC position.

Answers to Frame 6: _____ 1. __T__ 2. __T__ 3.

Frame 8

The OVERLOAD indicator, and the PUSH TO OPEN AND RESET control are both a part of the overload protection circuit. A red shaft will show in the overload indicator when the meter has been overloaded. To reset the meter for normal use, just take the meter leads out of the circuit, and push the "push to open and reset" control. To prevent your meter from overloading always set your range switch to its highest setting and work your way down.



Complete the statements below by filling in the blank spaces with the correct answers.

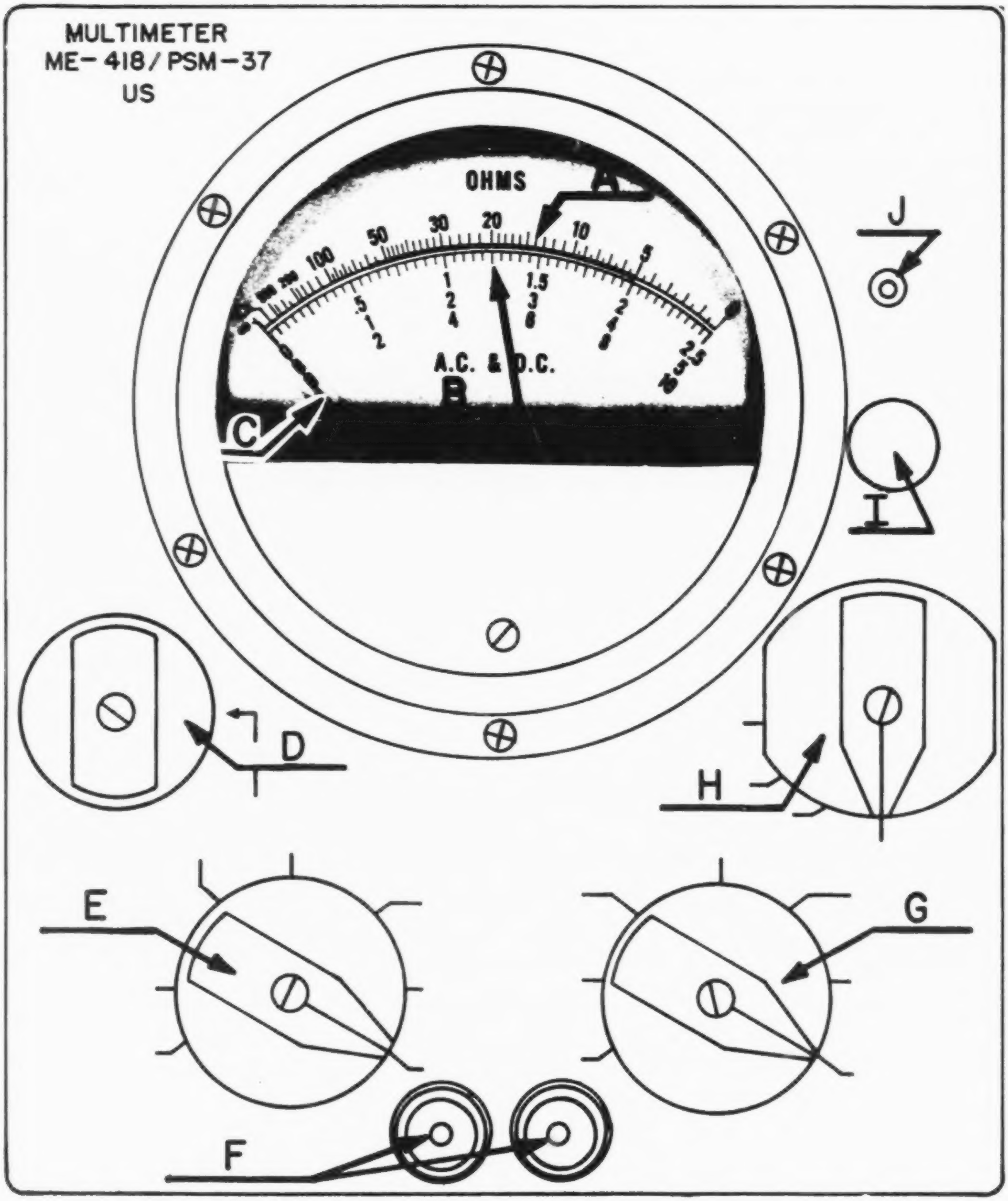
1. If too much voltage or current is applied to the meter, the

_______________ indicator will have a _______________ shaft appear in it.

2. After removing the meter from a circuit due to an overload,

you must push in the _______________ button.

Answers to Frame 7: 1. DC-, 2. AC, 3. polarity


MULTIMETER
ME-418/PSM-37
US
OHMS
A
B
C
D
E
F
G
H
I
J
A.C. & D.C.
100
50
30
20
10
5
.5
1
2
1.5
3
6
2
4
8
2.5

This illustration is to be used with the meter controls and function exercise on the next page.

Answers to Frame 8: 1. overload, red 2. push to open and reset

Frame 9 (cont'd)

The following exercise checks your knowledge of the meter control names, location and functions. Use the illustration of the meter on the preceding page to select the letter that corresponds to the name of that control. Place the letter you chose from the illustration in the "Meter Letter" column. Then match up the function of the controls in the "Function" column with the name of the control in the "Name" column. Place your letter choice in the "Function Letter."

	Name	Meter Letter	Function Letter
1.	Needle (Pointer)	C	(b)
2.	OHMS (Green)	____	( )
3.	OHMS Adj.	____	( )
4.	Test Jacks	____	( )
5.	Function Switch	____	( )
6.	Polarity Switch	____	( )
7.	PRESS TO OPEN and RESET	____	( )
8.	AC & DC	____	( )
9.	Overload	____	( )
10.	Range Switch	____	( )

Functions

(a) scale used to indicate voltage or current readings.

(b) aligns with the scale to indicate value measured.

(c) hook-up point for leads.

(d) used to break meter input circuit and reset overload protector.

(e) used to "zero" the pointer on OHMS scale.

(f) determines if meter measures OHMS, VOLTS, or AMPS.

(g) used to select the type of current or voltage to be applied to the meter.

(h) indicates values in OHMS.

(i) determines maximum value to be measured or multiplier for ohms.

(j) indicates excessive power has been applied to PSM-37.

The PSM-37 meter is built to measure many OHMS values. A look at the meter in front of you shows that there are six (6) positions for the ohmmeter function. They are R X 1, R X 10, R X 100, R X 1K, R X 10K and R X 100K. To measure resistance, the POLARITY switch must be turned to one of the DC positions (usually DC+); the RANGE switch must be set to one of the six positions listed above and the function switch must be set on OHMS. The OHMS position used in this block will be the STD position. (NOTE: The LP position is for testing low power devices and is used with the R X 1 position of the RANGE switch.) To measure resistance accurately, the ohmmeter must first be "zeroed". You zero the meter by touching the ends of the leads together with the meter set as you were told above. The meter needle should move to the zero end of the ohms scale. Note that the OHMS scale is GREEN. If the needle does not go all the way to zero, or goes past, then turn the OHMS ADJ knob is on zero. When the test leads are separated the needle should go back to the left end of the OHMS scale, over the infinity (∞) mark.

Use your PSM-37 and zero the ohmmeter in the R X 10 range position.

Note: The PSM-37 meter should not need to be rezeroed on each of the RANGE switch positions. Once zeroed, the meter should stay zeroed through all resistance range positions.

If your meter will not zero on any of the ranges, push the "Push to Open and Reset" button. If your meter still will not zero, ask your instructor for help.

Check the true statement(s).

_____ 1. With the function switch in OHMS STD and RANGE switch in R X 1, the meter can be zeroed on OHMS. (Use your meter and test this statement.)

_____ 2. The readings are taken from the green scale of the PSM-37 when the function switch is in the OHMS function.

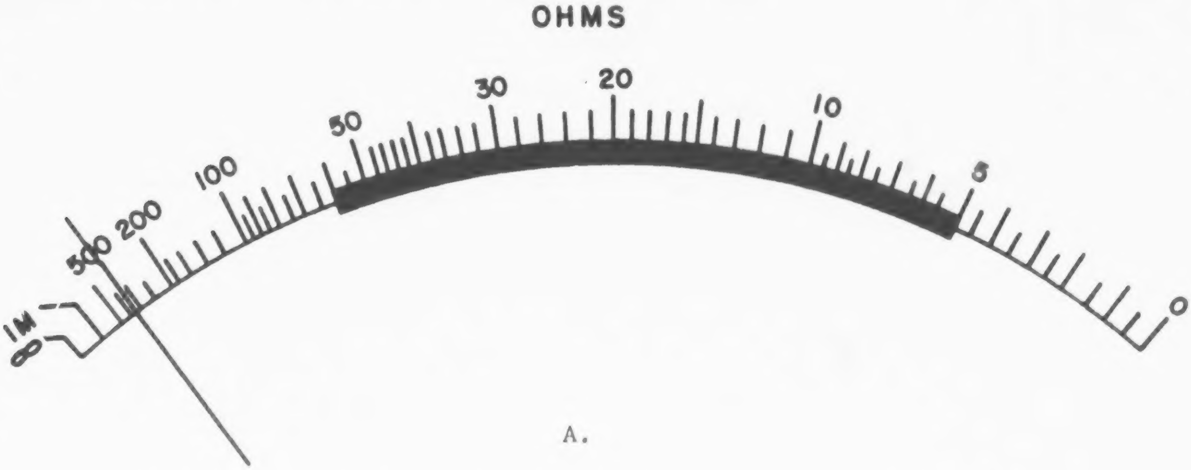
_____ 3. The PSM-37 meter needs only to be zeroed when you first start to use it as an ohmmeter.

_____ 4. The zero mark for OHMS is on the left side of the OHMS scale.

Answers to Frame 9: 1. C (b) 2. A (h) 3. D (e) 4. F (c) 5. E (f) 6. H (g) 7. I (d) 8. B (a) 9. J (j) 10. G (i)

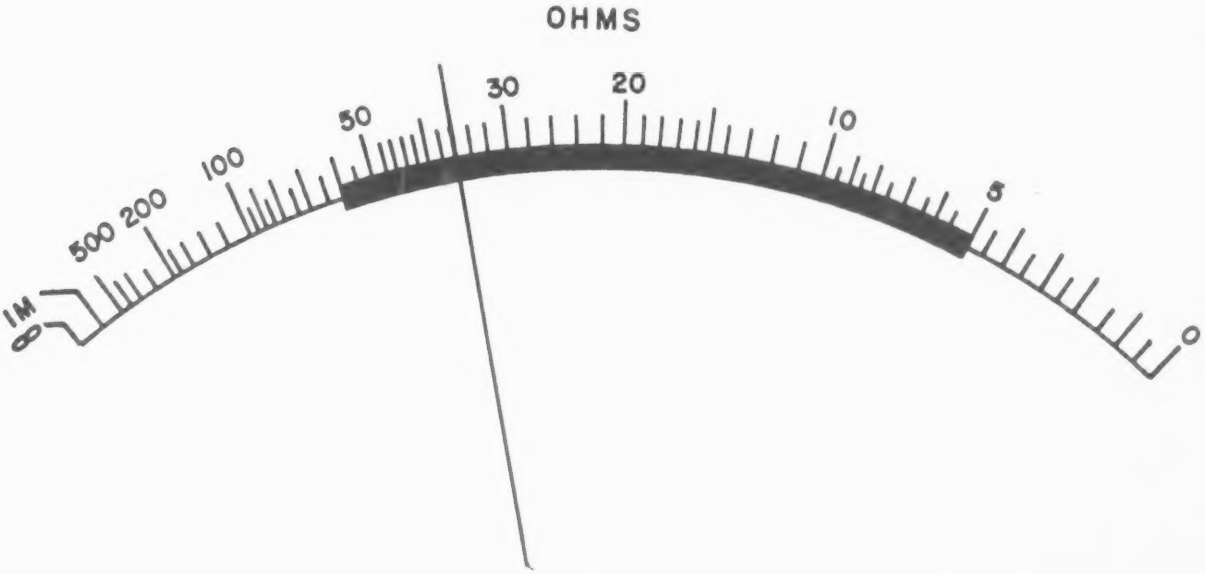
Frame 11

When you use the PSM-37 to check ohms, set the RANGE switch to a position where the needle rests in the wide green area of the OHMS scale. Try not to take the readings from any other part of the scale, if it is possible. We need to do this because the ohmmeter is less accurate from 0 to 5 and 60 to ∞. In example A, a resistor with an ohmic value of 360 ohms is being measured with the range switch in the R X 1 range. The meter needle is between the 300 to 400 marks, a difference of 100 ohms. Since the operator is forced to guess at the reading, a large margin for error can exist.



A.

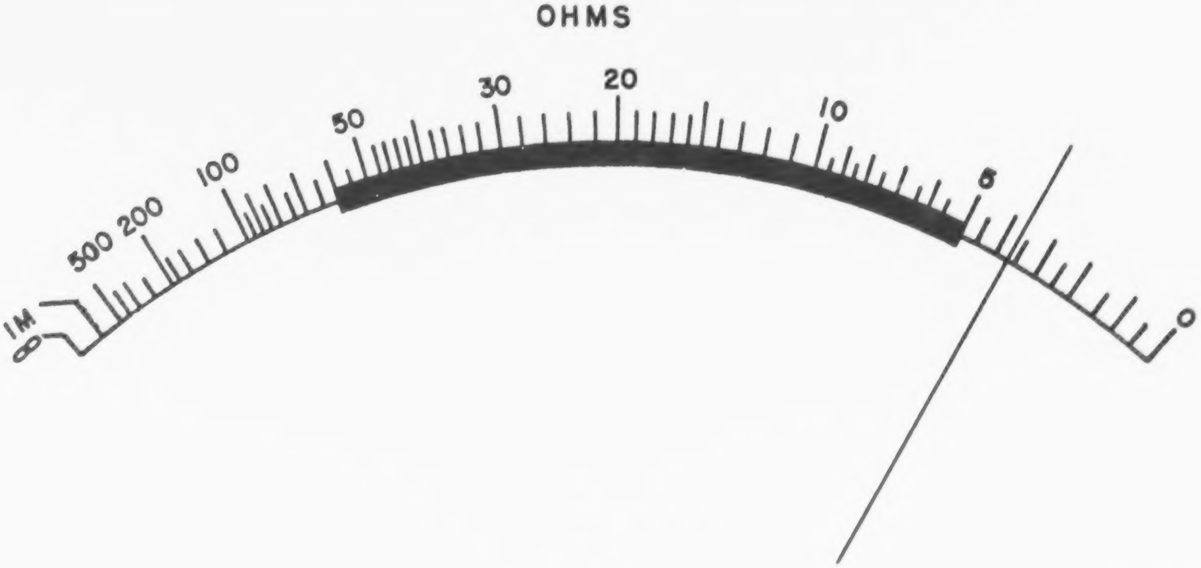
Example B shows the same resistance measured using the R X 10 range. Even though the operator must multiply the scale reading by 10, the reading is more accurate because each mark in this area of the scale is 20 ohms (marks are 2 points each times 10, equals 20). Then, the margin for error is reduced.



B.

Answers to Frame 10: ____ 1. ✓ 2. ✓ 3. ____ 4.

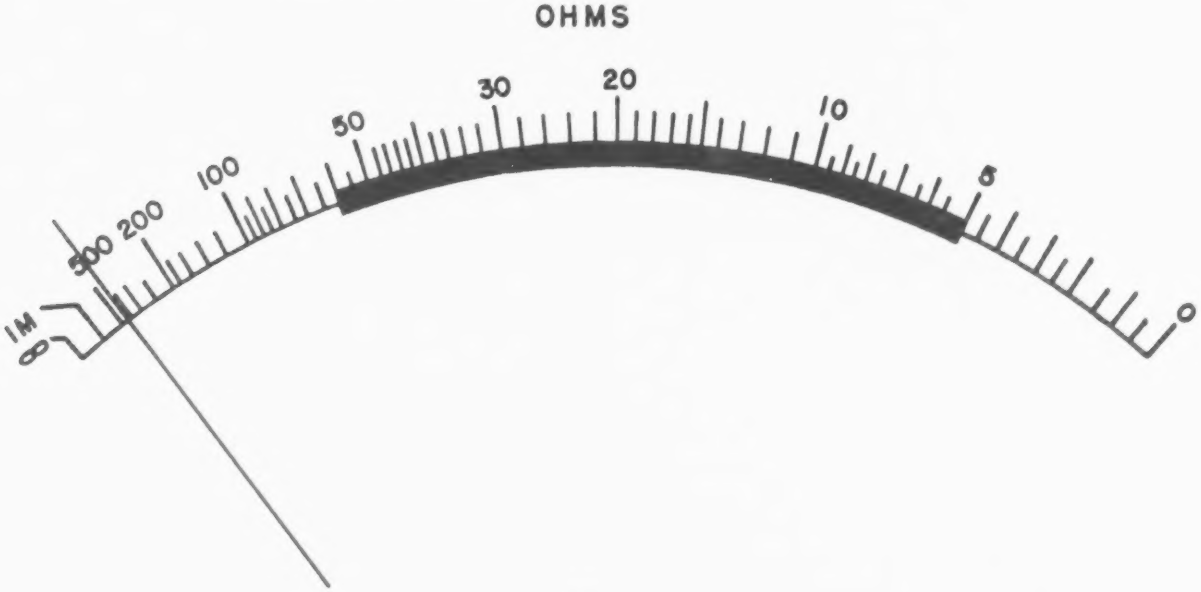
Example C shows a 360 ohm resistance reading on the R X 100 range. In this case you must multiply the scale reading by 100. The measurement is less accurate than B because each mark is worth 50 ohms (.5 X 100 equals 50). The margin for error is increased.


OHMS
30
20
50
10
100
5
500 200
1M
∞
0

C.

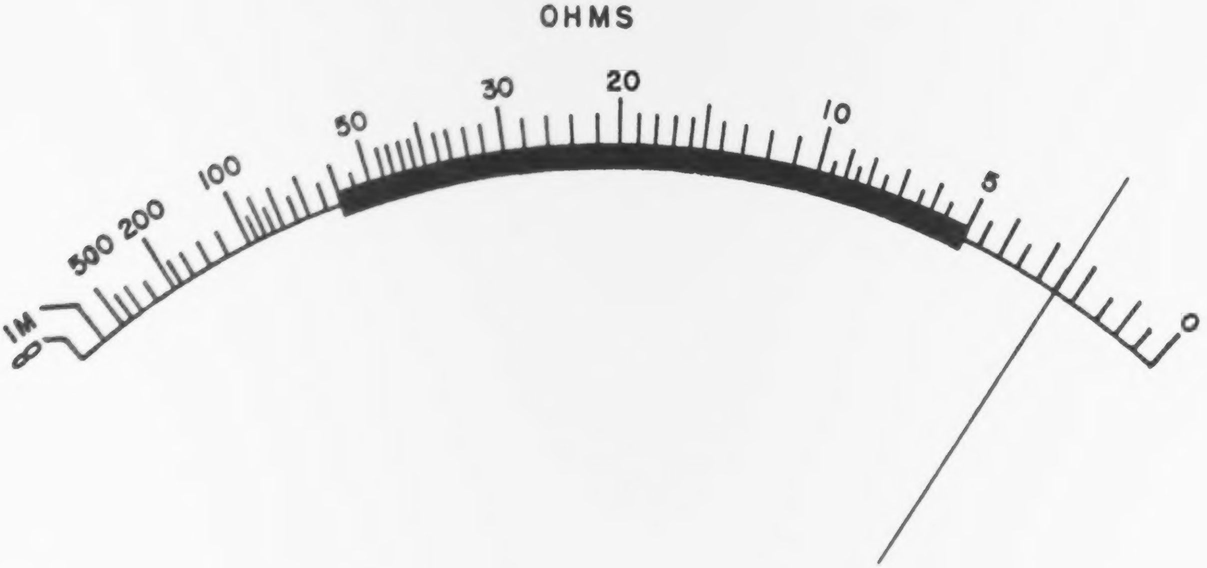
Study the ohmmeter scales shown below. Find out if the resistance is being read by the most accurate range. If the right range is used, write "OK" in the blank next to that scale. If the right range is not used, write the range which should be used.

1. 480 ohms, R X 1 range ____________________.

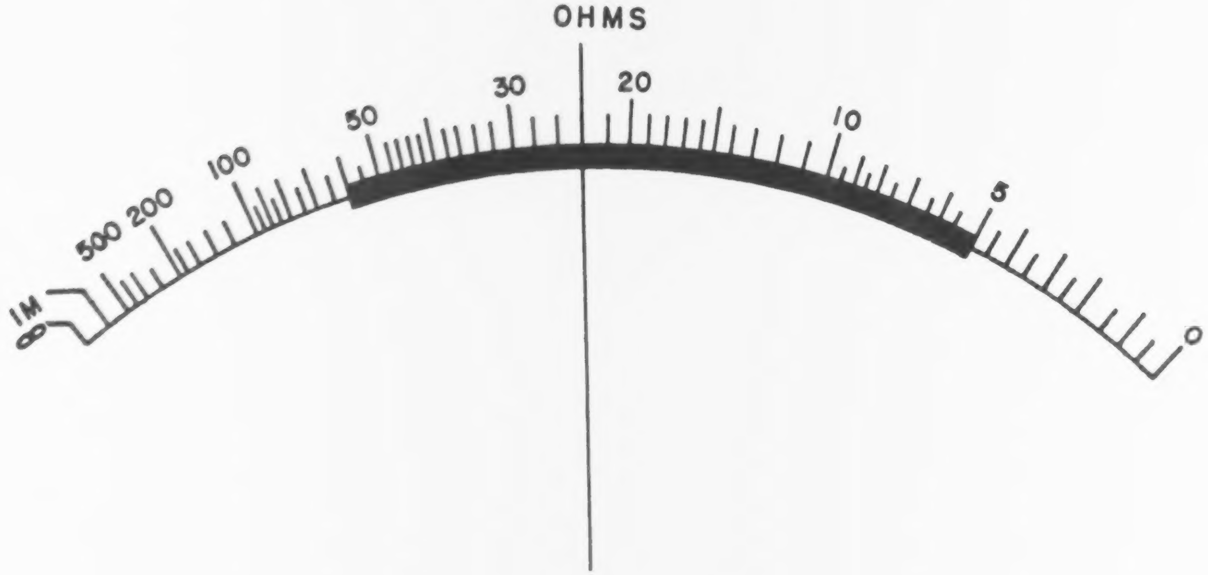

OHMS
30
20
50
10
100
5
500 200
1M
∞
0

Frame 11 (Cont'd)

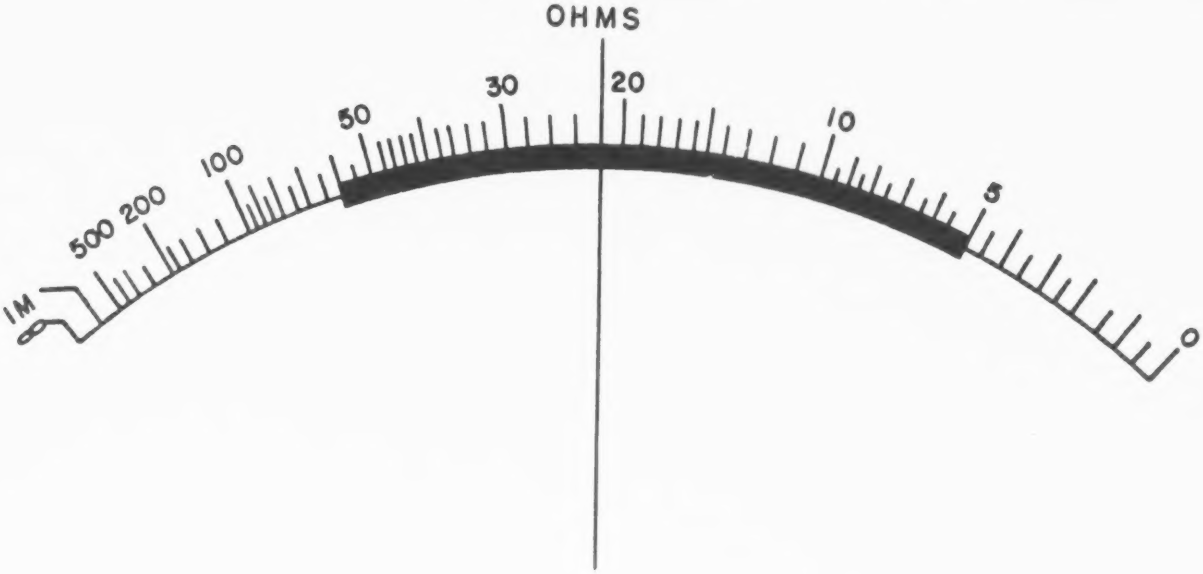
2. 25 ohms, R X 10 range ________________.


OHMS
1M
∞
500
200
100
50
30
20
10
5
0

3. 240 ohms, R X 10 range ________________.


OHMS
1M
∞
500
200
100
50
30
20
10
5
0

4. 2200 ohms, R X 100 _______________.


OHMS
1M
500
200
100
50
30
20
10
5
0

Frame 12

Before you take a resistance reading using the multimeter, you should zero the meter by touching the lead tips and using the adjustment knob to line up the needle upon zero. Remember that in the ohms position the meter creates its own current. So what is between the two leads is the only thing being read. There are different terms used when using the ohms portion of the multimeter. A "0" reading means continuity or no resistance in the circuit. A reading when the needle moves and stops short of "0" means your reading resistance. If the needle doesn't move at all, remains on infinity (∞), it means you are reading an open circuit.

Place a "T" in the blank space beside each true statement.

_____ 1. Continuity refers to the amount of resistance in an open circuit.

_____ 2. A resistance that is to large to measure is referred to as infinity.

_____ 3. When the pointer is reading a value other than "0", this means some resistance is present in the component being checked.

Place the correct response in the space provided.

Set up your meter to read 500 ohms of resistance. Place the position of your switches in the blanks below.

a. Range ____________________

b. Function ____________________

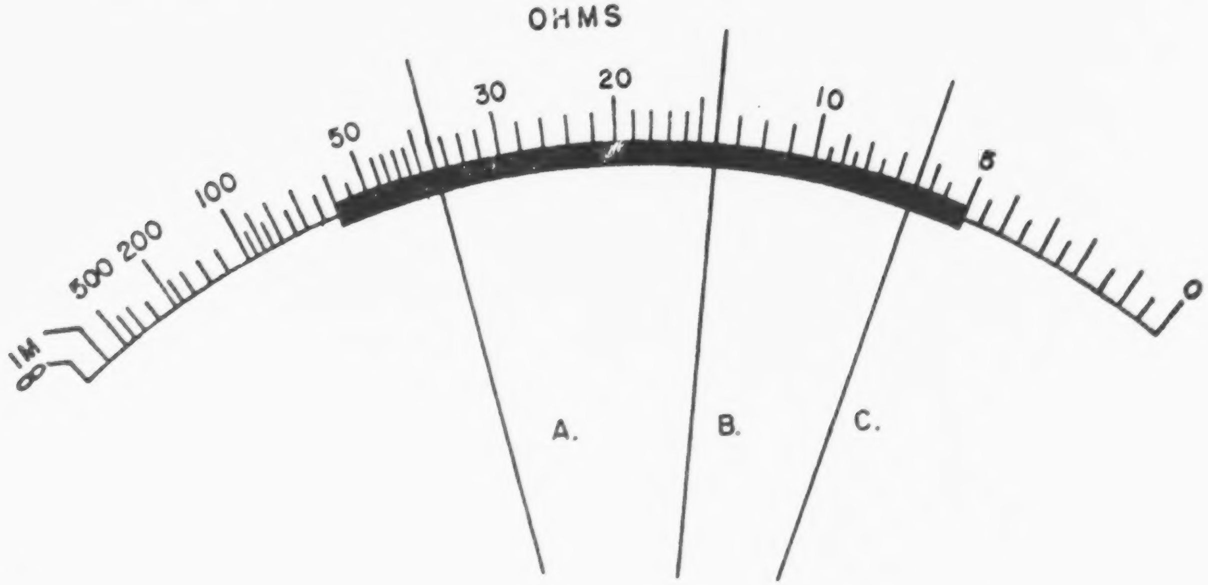
c. Polarity ____________________

Answers to Frame 11: 1. R X 10 2. R X 1 3. OK 4. OK

Frame 13

The ohms (green) scale is probably the most easy to read. The value of each mark on the scale stays the same for each position of the RANGE switch. For example, the numbers on the ohms scale will always be the same value; 5, 10, 20, 30, and so on. The RANGE switch is what determines what you multiply these numbers by to get the resistance reading of what you are measuring. This will be covered in the next frame.

You should not have any problem reading the meter when the meter's needle comes to rest on one of the larger numbered marks. However, if the needle falls between the numbered marks use the following steps to find the reading.



1. Needle A is resting between 30 and 50. Subtract 30 from 50 you get 20. (The difference between the two numbers 50 and 30.)

2. If counted there are 10 spaces between the 30 and 50. Divide the 10 spaces into the difference (you got from step one). This will give you 2. The 2 will be the value of each small mark.

3. Now start on the 30. Since you know the value of the small marks start adding up the marks from the 30 to get the actual meter reading.

Using the figure above, complete the following by filling in the blank with the correct response.

1. Needle B is indicating ____________________.
2. Needle C is indicating ____________________.
3. Each division mark between 20 and 30 is equal to ____________.
4. Each division mark between 50 and 100 is equal to ____________.

Answers to Frame 12: 1. _____ 2. T 3. _____
a. Rx10 b. OHMS-STD c. DC+

Frame 14

The illustration below shows the ohmmeter scale of the PSM-37. When measuring resistance in the R X 1 range, it is read just as is shown by the needle on the OHMS scale. With the RANGE switch in any of the other R X positions you would multiply the resistance reading (R) times the number at the R X position.

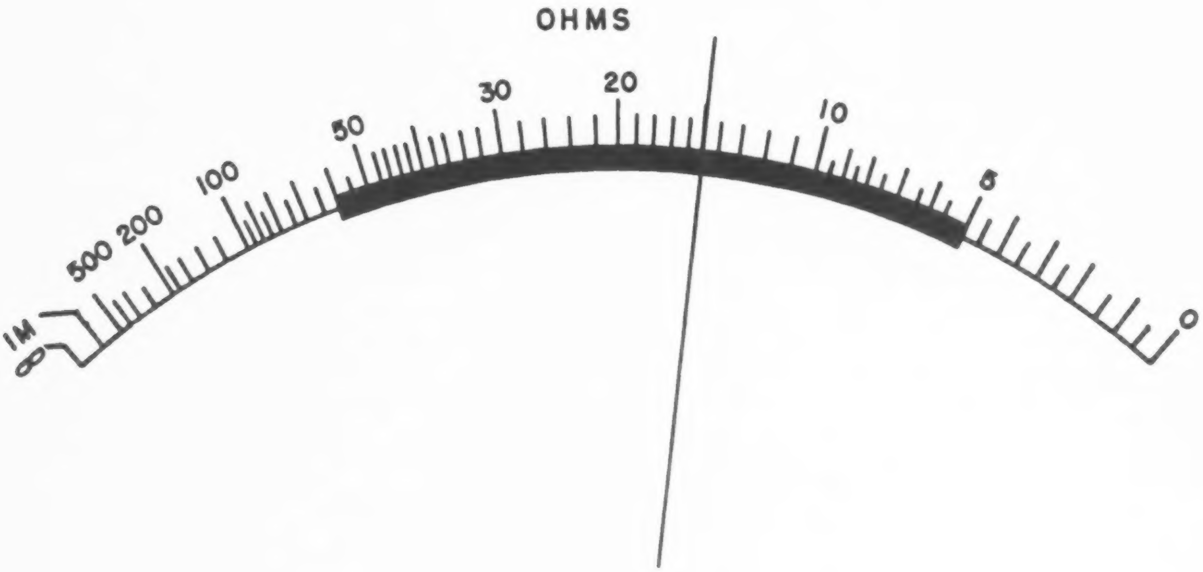
Example: In the R X 10 position the needle stops at the 30 mark on the OHM scale. You would take 30 times 10. The ohmic value you have measured is 300 ohms. In the R X 100 position it would be 30 times 100, which equals 3000 ohms.

When using the range switch setting with a K in it, for example, R X 1K, R X 10K, R X 100K, the K means Kilo or 1000. So the multiplier is red as shown below in the different range switch positions.

RANGE SWITCH	VALUE
R X 1K	R X 1,000
R X 10K	R X 10,000
R X 100K	R X 100,000

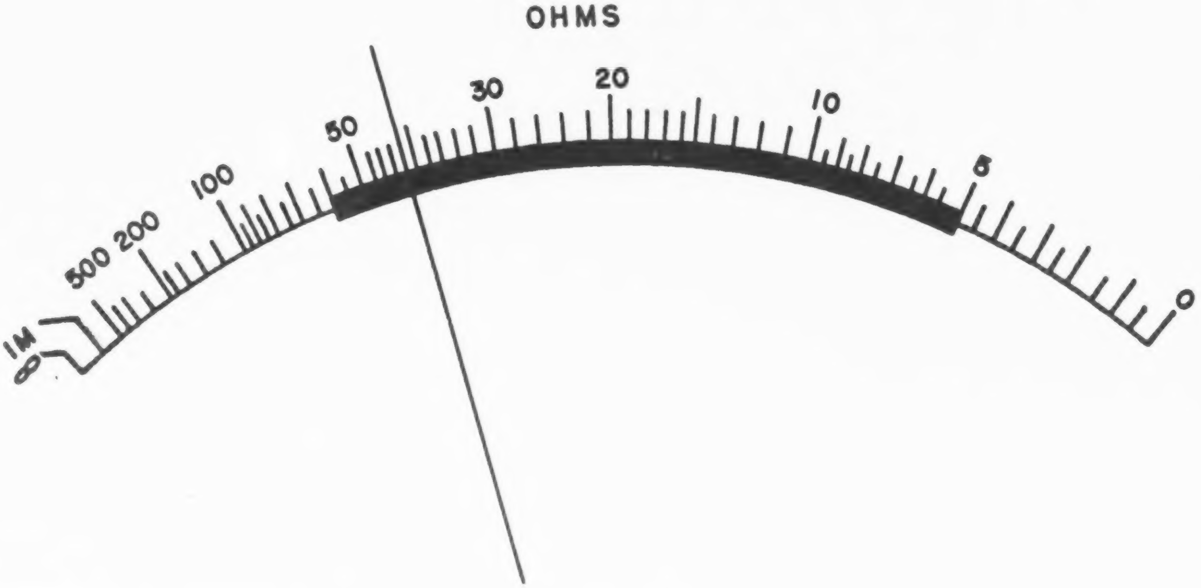
What resistance is indicated in each of the ohmmeter scales below?

1. R X 10 = ______________________.

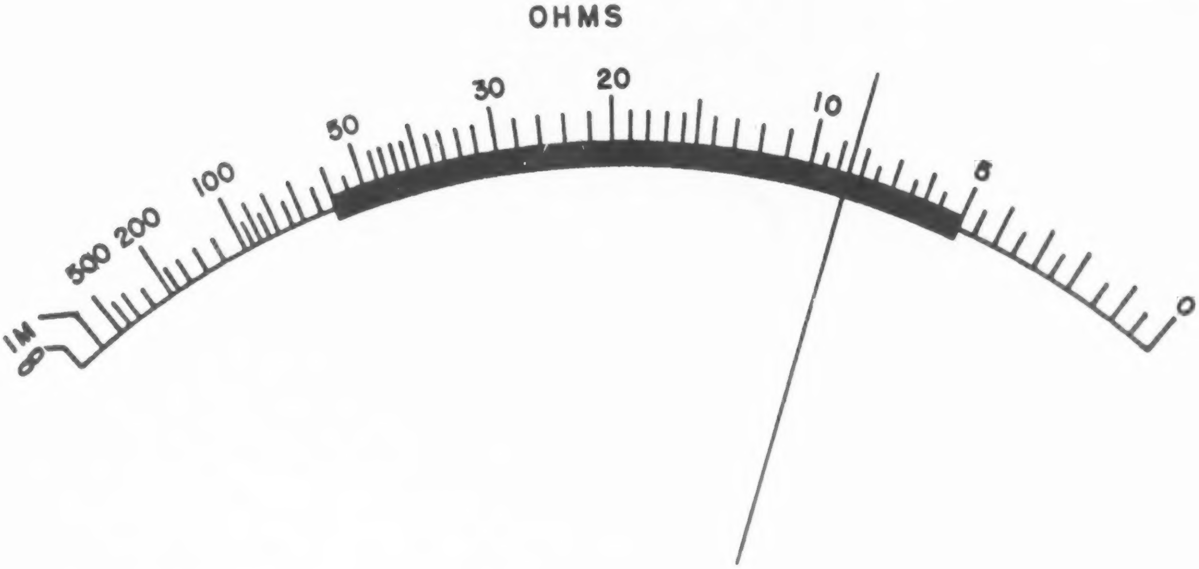


Answers to Frame 13: 1. 14 2. 6.5 3. 2 4. 5

2. R X 10K = ____________________.

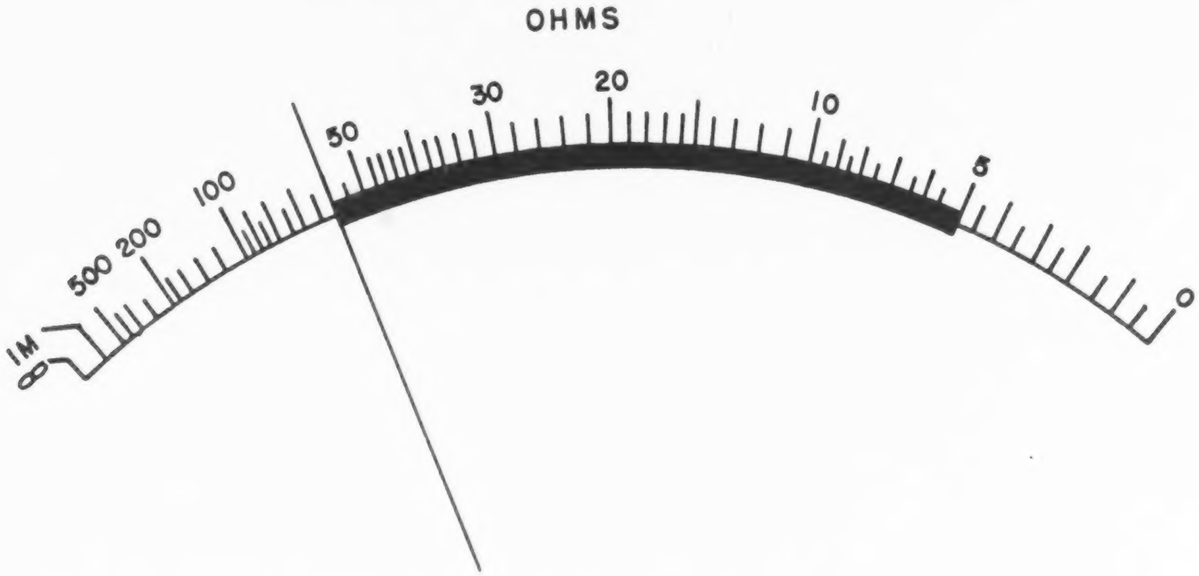

OHMS
50
30
20
10
5
0
100
500 200
1M
∞

3. R X 1K = ____________________.


OHMS
50
30
20
10
5
0
100
500 200
1M
∞

Frame 14 (Cont'd)

4. R X 1 ______________________________.


OHMS
1M
∞
500
200
100
50
30
20
10
5
0

In the next few frames you will be given several resistors and a multimeter. While using the ohmmeter you will measure the resistance level of these various resistors. Before we go on, there are some important safety factors to think about when using the ohmmeter.

1. The PSM-37 should never be handled carelessly; aside from being expensive, it is sensitive and delicate. Don't abuse it.

2. Never connect the ohmmeter to a circuit that has power on it.

3. Periodically check the strength of the internal battery. Accomplish this by zeroing the ohmmeter on each of the range switch settings. If it does not zero on all settings, the battery needs to be replaced.

No further response required, proceed to the next frame.

Answers to Frame 14: 1. 150Ω 2. 420,000Ω 3. 8,500Ω 4. 60Ω

Frame 16

You are now ready to take resistance readings on the trainer with the PSM-37. As you complete each of the following steps place a check by the number of the step. Ask the instructor for assistance if you need it.

_____ 1. Place your PSM-37 and this PT on any available power bench.

_____ 2. Obtain a voltage, current and resistance readings trainer from the storage cabinet and place it on the power bench.

_____ 3. Set up your PSM-37 for reading ohms. The POLARITY switch should be set at DC+, the FUNCTION switch should be set on OHMS STD and the RANGE switch should be set on the highest ohms setting and work your way down until your needle falls into the bold green area (5-60) on the ohms scale.

_____ 4. Be sure your meter is zeroed.

_____ 5. Place one of your leads on TP-13 and the other on TP-14. The polarity doesn't make any difference when reading the resistance of a resistor. (TP means test point.)

_____ 6. The resistance indicated on your meter is ___________ ohms.

NO FURTHER RESPONSE REQUIRED, PROCEED TO THE NEXT FRAME.

Answer to Frame 15: No Response Required

Frame 17

In this frame you will get practice reading resistance with the ohms function of the PSM-37. Remember to set the range switch to a position where the needle rests in the wide green area of the ohms scale before taking your readings. Be sure to zero your meter before starting. When you have completed the following problems report to the instructor.

For each of the following pairs of test points indicate on the blank the amount of resistance your meter is indicating.

TP	READING
3 & 4	
5 & 6	
11 & 12	
17 & 18	
23 & 24	
25 & 26	
29 & 30	
33 & 34	
37 & 38	

Instructor's Initials ________________

Answers to Frame 16: 6. 90

Frame 18

Now we will discuss the measuring of voltage using the multimeter. Look at the face of the PSM-37 meter in front of you. The AC & DC scales are printed in black. The FUNCTION switch has three VOLTS positions. While in this block we will have you use the 1KΩ/V position. The only difference between the three positions is in circuit loading and this is of no importance to you at this point. On the lower right side of the meter face is the RANGE switch. This switch is very important since it is used to select the maximum value the meter can measure in volts and current. If you select the wrong range, it could damage the meter.

Look at the AC & DC scale. You will notice that there are three sets of numbers. In the space below, write the range for each set of numbers. The first one has been done for you.

Top Scale: Numbers range from 0 to 2.5.

Middle Scale: Numbers range from _________ to __________.

Bottom Scale: Numbers range from _________ to ___________.

The number to the far right of each scale shows the maximum deflection of the meter's needle. The values of these numbers (2.5, 5, and 10) will depend on where the range switch is set. There are seven ways to set the range switch: .5, 2.5, 10, 50, 250, 500 and 1,000. These numbers show the highest value which can be read with the meter for any of the settings of the range switch. For example, if the range switch was set at 250, the maximum value that could be checked with the meter would be 250. This value may be in volts or milliams. If more than 250 were applied to the meter, it might be damaged.

Fill in the blanks with the correct number.

1. If the range switch is set at 50, the maximum voltage that can be measured would be ________________.

2. If the range switch is set at 2.5, the maximum voltage that can be measured would be ____________________.

3. If you wanted to measure a voltage, the value of which would be between 250V and 500V, the RANGE switch would have to be set at the ________________ position.

Answers to Frame 18: 0 5
0 10

Frame 20

Since there are seven ways to set the range switch and only three different scales, each scale is used by several range positions. The 2.5 and 250 range switch positions use the top scale (0-2.5). The .5, 50, and 500 ranges use the middle scale (0-5). The 10 and 1000 range use the bottom scale (0-10). Do not try to memorize these as they are easy to figure out. Always take the first number of the range position and you pick the scale that matches that position. For example, the 250 position would be read on the (2.5) scale - notice they both start with the number two. Look at the chart below for further examples.

Figure 3 x 7", use negative of figure on page 28,
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Place either 0-2.5 or 0-5, or 0-10 in the spaces provided to indicate the scale that would be used for each of the range switch settings. The first one has already been done for you.

Range Switch Set at		Scale Used
.5	a.	0-5
2.5	b.	
10	c.	
50	d.	
250	e.	
500	f.	
1000	g.	

Answers to Frame 19: 1. 50V 2. 2.5V 3. 500V

In the last frame you learned how to choose the right scale for each range position. With the RANGE switch set on 50, the readings are read from the 0-5 scale. Since the meter can now only read a maximum of 50, the number 5 will mean 50. The 4 will mean 40, the 3 will mean 30, and so on. Notice that the changing of 5 to 50 resulted in the maximum number on the scale matching the RANGE switch position, and the other numbers change by the same amount (multiplied by 10). The way to determine the value of the maximum number on the scale is: it must be changed to equal the range switch position. Example: The range position of 250 uses the 0-2.5 scale. The 2.5 will now mean 250, the 2 will mean 200, the 1.5 will mean 150, and so on.

For all the exercises below, the POLARITY switch is set on "DC+," the FUNCTION switch is set on 1KΩ/V VOLTS. What is the voltage indicated on each of the following scales for each of the RANGE switch positions? The first one is completed for you.

1. Use figure A.

a. 50 range 40V DC

c. 500 range __________

b. 1000 range __________

d. .5 range __________

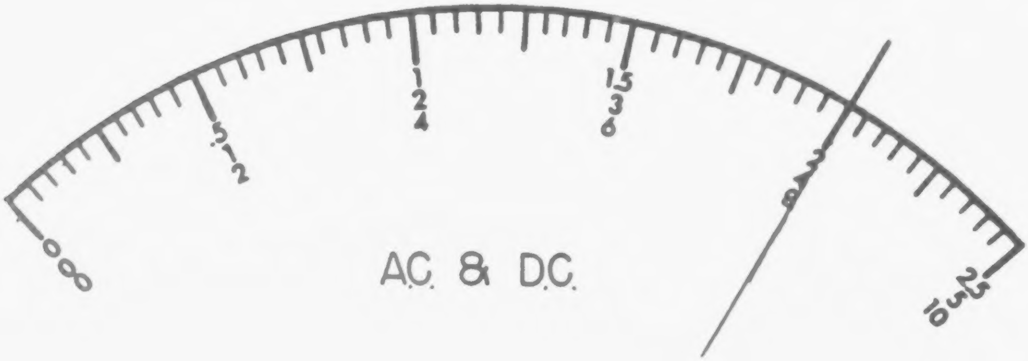


Figure A.

Answers to Frame 20: b. 0-2.5 c. 0-10 d. 0-5 e. 0-2.5
f. 0-5 g. 0-10

Frame 21 (Cont'd)

2. Use figure B.

a. 2.5 range ________________ c. 250 range ____________

b. 10 range ________________ d. .5 range ____________

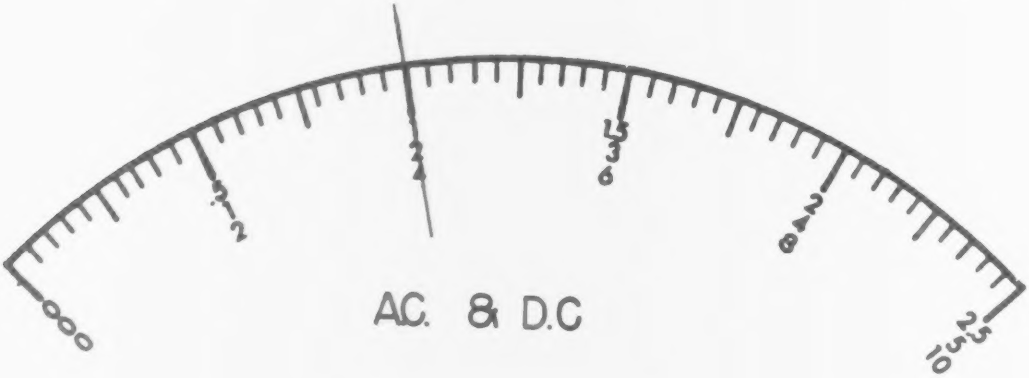

000
.5
1
2
1
2
4
1.5
3
6
2
4
8
2.5
5
10
AC. & D.C

Figure B.

The maximum value of each scale is determined by the position of the RANGE switch. With the RANGE switch at the 10 range, the 0-10 scale is read as is, Max 10. The difficulty in reading the scale comes when the needle stops on one of the small marks between the numbers. To find the value of each mark on the scale, divide the RANGE switch position by 50. Example: RANGE switch in 10 range, divide 10 by 50 to get .2. Each marking on the 0-10 scale is worth .2 points a piece. See figure A below. When you start at zero, you would count the marks, 0, .2, .4, .6, .8, 1 - - - - - - - - - 9.2, 9.4, 9.6, 9.8, 10. You use the same procedure to find the value of the small mark for each of the RANGE switch positions. The reason we use 50 as the denominator is there are 50 marks along the AC & DC scale. Since the scale is evenly spaced and marked, you can use the 50 as the denominator on all range positions and scales.

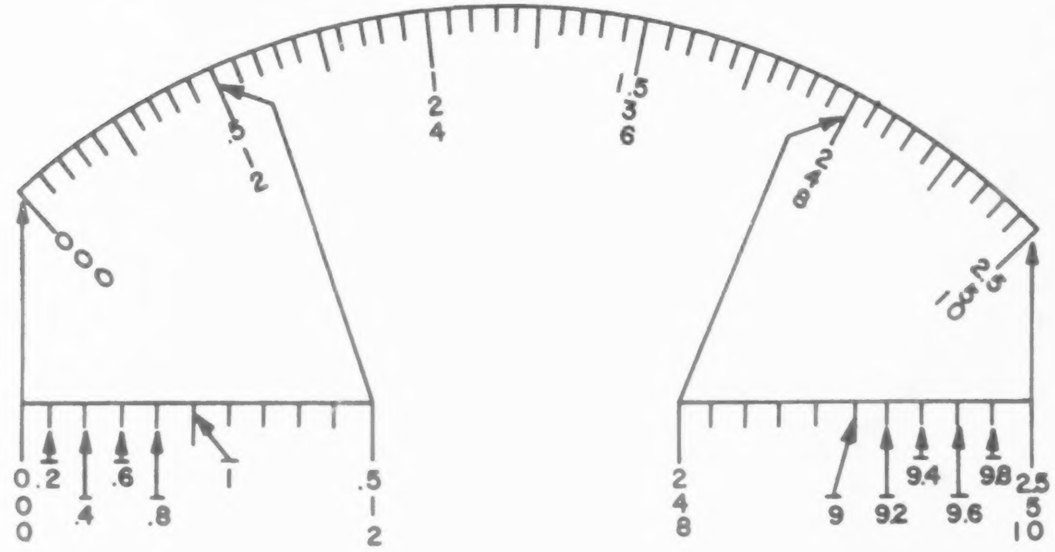


Figure A.

Answers to Frame 21: 1. b. 800V DC c. 400V DC d. .4V DC

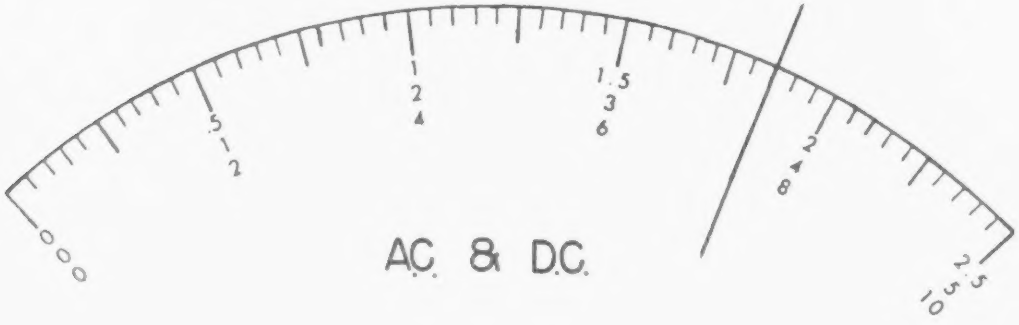
2. a. 1V DC b. 4V DC c. 100V DC d. .2V DC

Frame 22 (Cont'd)

Fill in the blanks with the appropriate response for the scale used and the value of each black mark on the scale. The first one is accomplished for you.

Range Switch Set At		Scale Used		Value of Each Mark
.5		0-5		.01
2.5	a.		b.	
10	c.		d.	
50	e.		f.	
250	g.		h.	
500	i.		j.	
1000	k.		l.	

The following exercise is to insure your ability to interpret meter indications in various RANGE switch positions, plus check your meter ability to determine the value of each mark on the meter scales. Fill in the correct answer in the appropriate space for each of the following items. Number one is completed for you.



Range Switch Set At	Value Indicated
1. .5	.37
2. 2.5	
3. 10	
4. 50	
5. 250	
6. 500	
7. 1000	

Answers to Frame 22: a. 0-2.5 b. .05 c. 0-10 d. .2 e. 0-5 f. 1. g. 0-2.5 h. 5. i. 0-5 j. 10 k. 0-10 l. 20

Frame 24

When you want to read DC voltage it is important to have the meter set up right. The FUNCTION switch set to VOLTS (in school, 1KΩ/V position); the POLARITY switch set to the polarity of the voltage applied to the RED test lead; (Note: In most cases, this will be positive and the polarity switch will be set at "DC+".) the RANGE switch will be set to the value of the voltage to be read. For example, if the voltage to be read is 8 volts DC, the RANGE switch would be set at 10. It is important to keep in mind the range switch sets the maximum value the meter can read; so, set the RANGE switch above the value to be read. When you want to read an unknown voltage, start with the range switch at the highest value. Then, turn the RANGE switch to a lower setting until the meter shows a voltage value. This procedure is a good practice to follow, regardless of what you are measuring.

Fill in the blanks with the correct switch position. For practice, set your meter up to measure the voltage in problem number one.

1. If you knew that you were going to measure approximately 120 volts DC, the RANGE switch would be set at ______________, the POLARITY switch set at DC+ and the FUNCTION switch set at ______________.

2. If you didn't know the approximate value of the voltage that you were measuring, you would use the ____________ range first.

3. A negative voltage polarity is applied to the RED test lead, the POLARITY switch would be set at _________________.

Answers to Frame 23: 2. 1.85 3. 7.4 4. 37 5. 185 6. 370 7. 740

When you use a voltmeter, you have to be sure the readings are as true as you can get them. Always choose the RANGE switch position which will cause the meter needle to move as far to the right as it can without going past the maximum value. For example, you could read 2 volts DC on the PSM-37 in front of you by setting the RANGE switch on 10 and read the voltage value off the bottom scale (0-10). But, it would be better if you set the RANGE switch to 2.5 and read the voltage on the top scale (0-2.5). By doing this, you can get more needle deflection than if you had set the RANGE switch on 10. Thus making your reading more accurate.

Fill in the blanks with the correct positions.

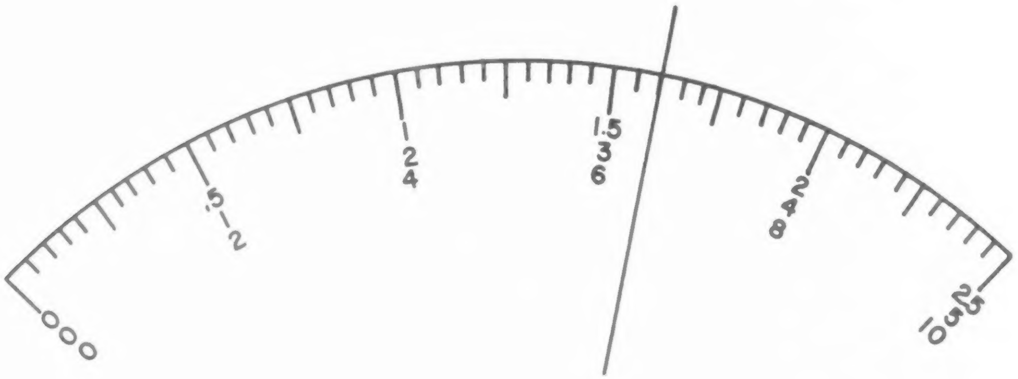
1. Look at the meter in front of you. If you were going to measure approximately 300V, you would have to set the range switch at ____________ to get the most accurate reading.

2. If you wanted to accurately measure 30V, you would have to set the range switch at ______________.

Answres to Frame 24: 1. 250, VOLTS (1KΩ/V) 2. 1000 (highest)
3. DC-

Frame 26

1. Fill in the correct answers in the appropriate spaces for the meter scale shown below. The FUNCTION switch set at VOLTS (1KΩ/V), and POLARITY switch set at DC+.



Range Switch Setting	Indication
a. .5	
b. 2.5	
c. 10	
d. 50	
e. 250	
f. 500	
g. 1000	

2. For each of the following voltages, indicate on the blank, the range that should be used to obtain the most accurate readings.

Voltage	Range Switch Setting
a. .15	
b. 1.5	
c. 15	
d. 150	
e. 750	

When reading AC voltages, it is done in the same way as explained for DC. The only change is that you put the polarity switch to AC.

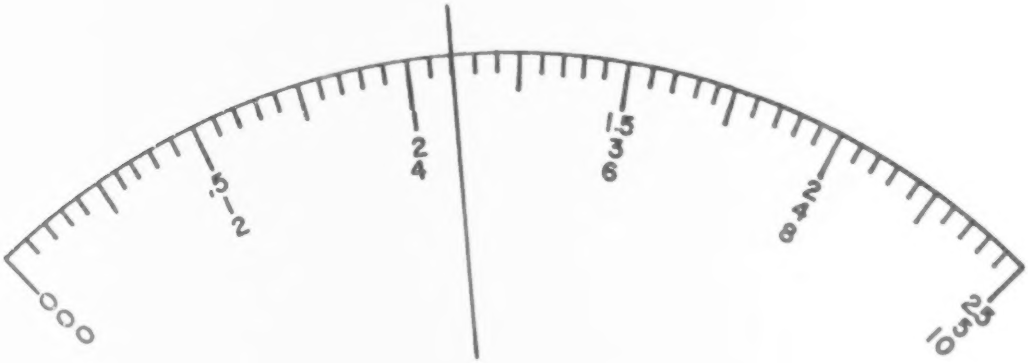
Answers to Frame 25: 1. 500 2. 50

Frame 27

When using the multimeter to read current, you use the same scales as you used to read volts. To measure DC milliamperes (MA) set the POLARITY switch to the "DC+", set the FUNCTION switch to "MA/PULSE MA", and set the RANGE switch to the value that you wish to measure.

The PSM-37 can read up to 1000 MA which is the same as one ampere. To change MA to amps, move the decimal point three places to the left. Example: 1000 MA is 1 amp, 200 MA is .2 amp. To change amps to MA, move the decimal point three places to the right; 1 amp is 1000 MA, and .5 amp is 500 MA.

> Note: The POLARITY switch position is determined by the polarity of the current applied to the RED test lead. Fill in the correct answer in the appropriate space for the following items.



1. FUNCTION switch set at AMPS, MA position.

   a. RANGE switch set at 1,000. Current indication is _____ MA or _____ amps.

   b. RANGE switch set at 500. Current indication is _____ MA or _____ amps.

   c. RANGE switch set at 250. Current indication is _____ MA or _____ amps.

   d. RANGE switch set at 10. Current indication is _____ MA or _____ amps.

Answers to Frame 26: 1.a. .32 b. 1.6 c. 6.4 d. 32 e. 160
f. 320 g. 640
2.a. .5 b. 2.5 c. 50 d. 250 e. 1000

Frame 27 (Cont'd)

2. Set your meter up to measure 22 MA DC.

   a. The RANGE switch setting is ________.

   b. The POLARITY switch setting is ________.

   c. The FUNCTION switch setting is ________.

When you use the PSM-37 as an ammeter, and you are checking an unknown value, you will start on the highest range (1000) of the RANGE switch and work the switch down to the most accurate range. You should note that the most accurate reading on the AC & DC scale will be made when the needle moves as far right on the scale as it can, and still not go past the end of the scale. Just as is done when reading voltage.

Fill in the blanks below with the most accurate range switch position for each of the readings given. You may refer to your PSM-37 for a list of the ranges.

READINGS	RANGE	READINGS	RANGE
1. 40 MA	_____	4. 225 MA	_____
2. 400 MA	_____	5. 11 MA	_____
3. 4 MA	_____	6. 600 MA	_____

Answers to Frame 27: 1. a. 440 MA, .44a b. 220 MA, .22a

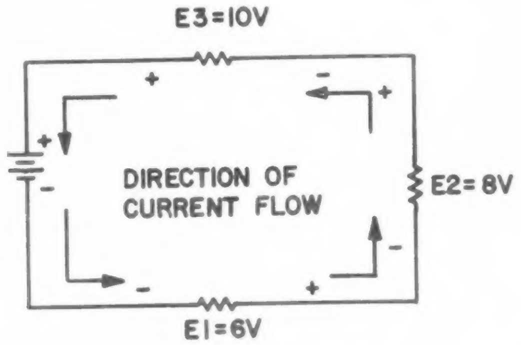
c. 110 MA, .11a d. 4.4 MA, .0044a 2. a. 50 b. DC+

c. AMPS MA

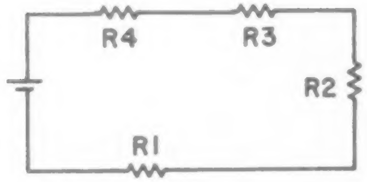
Frame 29

You have learned that the word direct means to go one way and current means the flow of electrons. Join the two words and you have direct current (DC). They mean a current that flows in one direction all the time. The flow will be from negative (-) to positive (+). Any time current flows in a circuit, voltage will be used up (dropped) by the circuit's loads. The polarity of this voltage drop can be found by the way that current flows through the component. In the circuit below, note that current is leaving the negative post of the battery, flowing through the circuit and returning to the positive post. As the current goes in a resistor, it will cause that end of the resistor to have a negative polarity. When it leaves a resistor it leaves that end with a positive polarity. This is true in all DC circuits.

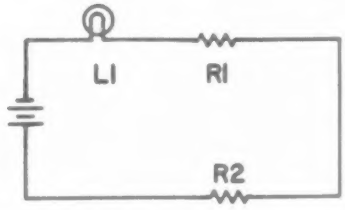
Note: If the power source is not a battery, the negative side is sometimes marked "-" or is black; the positive side is marked "+" or painted red.



Place the right polarity to the components of the two circuits below. Also, point out with an arrow, the direction of current flow in the circuit.



CIRCUIT A



CIRCUIT B

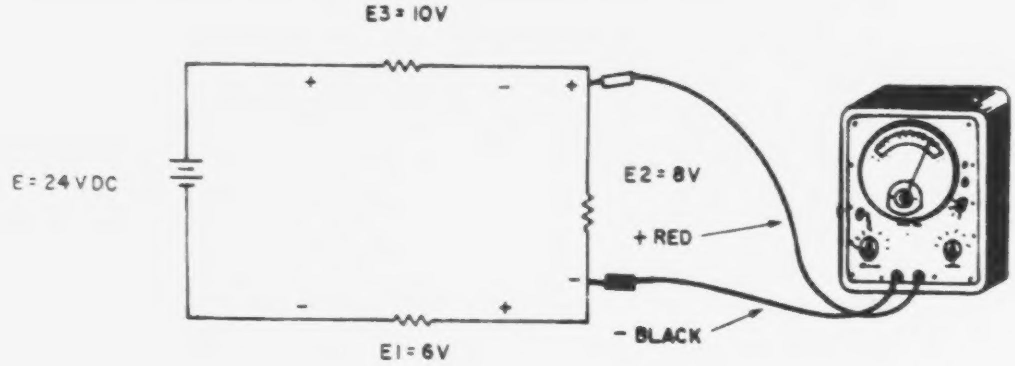
Answers to Frame 28: 1. 50 2. 500 3. 10 4. 250 5. 50

6. 1000

Frame 30

When you test for voltage on a DC circuit you must watch the polarity of the voltage drop before you place the test leads in the circuit. Once you know the polarity, place the black lead of the voltmeter to negative and the red lead to positive. The meter must be connected across (in parallel with) the component being measured, as shown in the diagram below. If you place the meter or leads in some other manner, you will have a wrong reading. Plus, it could damage the meter.

> Note: Another thing that is important before you test for DC voltage, is that you should have your PSM-37 set up for the polarity value and the type of voltage that you will test.



In this manner, the voltmeter is connected in parallel.

Select the correct word and place it in the blank space to complete statements one, two, and three. For item four, fill in the blanks with the correct position of the switches.

1. When using the PSM-37 as a voltmeter, you would connect

the meter in ____________ (series/parallel) with the voltage to be measured.

Answers to Frame 29:

Figure 1 1/2 x 5 1/2", use negative of figure on page 41, ST C3ABR42331-PT-112, 19 Nov 82, RSN 83-69232

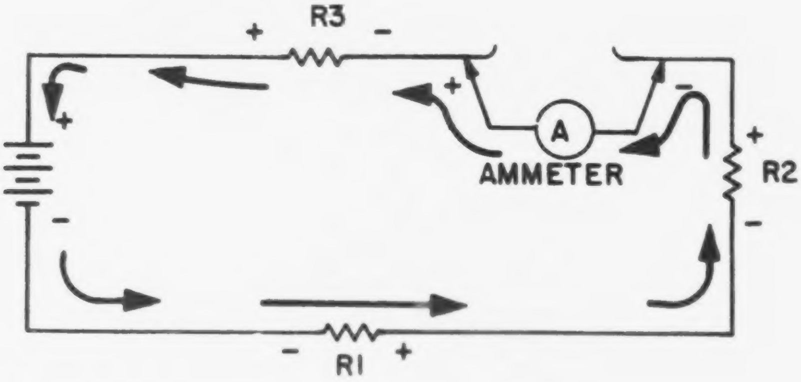
Frame 30 (Cont'd)

2. If the meter is connected in series when making voltage checks, the readings will be ____________ (accurate/inaccurate).

3. To measure the voltage E3 in the circuit above, the red lead will be placed on the __________ (right/left) of the resistor and the black lead on the ________ (other/same) end of the resistor.

4. Set your PSM-37 to measure the voltage E1 in the circuit above. The range switch position is __________, the polarity switch position is _____________, and the function switch is set at _________.

To measure amperage, you must connect the meter to the circuit in such a way that it becomes a part of the circuit, or in series. When you connect it in series the same current that flows through the circuit will flow through the PSM-37. Do not place an ammeter in parallel to measure current. If you do, the meter can be damaged or the reading you take will be inaccurate and low. The circuit below shows you an ammeter that is properly placed in a DC circuit. The polarity of the circuit must be observed when hooking up for current (read lead +, black lead -).



Identify the true statement(s) by placing a T on the blank spaces provided.

_____ 1. The ammeter must be connected in series with the circuit component being checked.

_____ 2. To accurately measure current, the same current must flow through both the meter and the circuit component being checked.

_____ 3. If the PSM-37 is connected in parallel to measure current, the readings would be inaccurate and low.

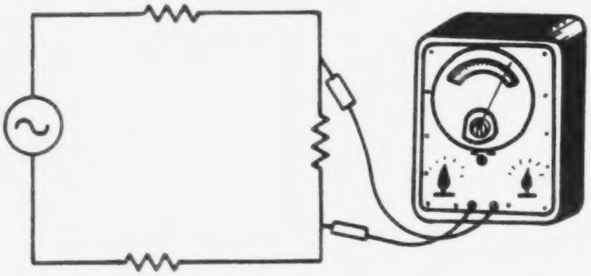
Answers to Frame 30: 1. parallel 2. inaccurate 3. left, other

4. 10, DC+, VOLTS - 1KΩ/V

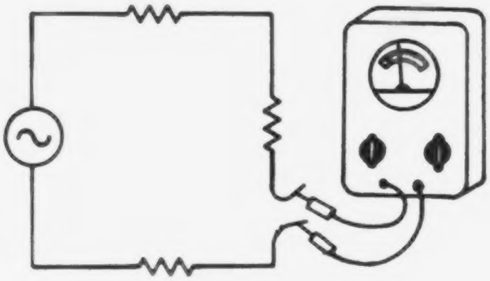
Frame 32

When you use the PSM-37 to measure the volts or amps in an AC circuit it is the same way as for DC circuits. The one difference is you do not need to observe polarity since AC means alternating current; a current that will first flow in one direction and then it will flow in the opposite direction.

To use the PSM-37 as an AC voltmeter, you must set the controls up properly; plus, you must place the meter in parallel with the voltage that you will test. For AC current measurements you must set the controls up properly, and you will connect the meter in series with the circuit.



Meter in PARALLEL TO
measure AC voltage drop



Meter in SERIES to measure
AC current flow

Place a checkmark (✓) beside the true statement(s).

_____ 1. You must observe polarity when measuring volts or amps in an AC circuit.

_____ 2. An ammeter is connected in series to measure voltage in an AC circuit.

Answers to Frame 31: 1. T 2. T 3. T

Before we begin to take some voltage and current readings using the multimeter, lets observe some safety precautions.

1. When measuring unknown voltages and currents, start your check with the RANGE switch set on "1000". Then turn it to a lower setting if necessary. Then return it to the "1000" range. This way the meter will be ready for the next check.

2. When used as a voltmeter, connect it in "parallel" with the voltage drop being checked.

3. When measuring DC voltage and DC current, be sure to observe polarity when connecting the meter to the circuit. Note if the meter needle moves left on the scale, either reverse meter nears on the circuit or turn the polarity switch to the other DC position.

NO RESPONSE REQUIRED, go on to the next frame.

Answers to Frame 32: 1. _____ 2. _____

Frame 34

In this frame you will use the PSM-37 to take actual readings. As you complete each of the following steps place a check on the blank by the number of the step.

_____ 1. Place your PSM-37 and this PT on any available power bench.

_____ 2. Obtain a voltage, current, and resistance readings test board from the storage cabinet and place it on your power bench.

_____ 3. Be sure that the three circuit switches on the voltage, current, and resistance readings test board are in the "OFF" position.

_____ 4. Be sure that the three switches on the power bench are in the "OFF" position.

_____ 5. Place the power bench's DC RANGE SWITCH to the 24V position.

_____ 6. Connect one end of the DC power cord to the voltage, current, and resistance readings test board and the other end to one of the DC outlets on the power bench. The DC power cord is kept in the drawer. Also connect the AC power cord the same manner.

_____ 7. Be sure that the AC and DC both rotary switches mounted on the back of the voltage, current, and resistance readings test board are in the number 1 position.

_____ 8. Place your PSM-37 on the top of the power bench.

_____ 9. Place your meter leads in the test jacks of your meter.

_____10. Place the black lead of your PSM-37 into the GROUND jack (at center) of the voltage, current, and resistance readings test board.

_____11. Set the polarity switch of your PSM-37 to DC+.

_____12. Set the FUNCTION switch of your PSM-37 to the V-1KΩ/V position.

_____13. Since you set the DC RANGE SWITCH on the power bench to 24V, you will not have a reading higher than 24V. Thus, you can safely start on the 50V range of your PSM-37. Set the RANGE switch of your PSM-37 to the 50 position.

Answer to Frame 33: No Response Required

_____14. Push in the power bench's TRAINER POWER PANEL SWITCH and 28V DC POWER PANEL SWITCH circuit breakers.

_____15. Place both the TRAINER POWER SWITCH and the 28V DC POWER PANEL SWITCH on the power bench to the ON position.

_____16. Place the DC VOLTAGE SWITCH on the voltage, current, and resistance readings test board the "ON" position. This is circuit #1.

_____17. Touch the probe of the positive lead to test point A (TP-A) in circuit 1. Be sure that your fingers do not touch the metal probes when taking readings.

_____18. You should notice a very small deflection on your meter. Since your meter is reading less than 10V you can safely set the RANGE switch of your PSM-37 to the 10 position. Set the RANGE switch of your PSM-37 to the 10 position.

_____19. Your PSM-37 should be indicating approximately 1V. Since this reading is less than 2.5V, you should use the 2.5 range to get the most accurate reading. Set the RANGE switch of your PSM-37 to the 2.5 position.

_____20. What is the PSM-37 reading now? __________ It should read approximately 1.15.

Frame 35

Take DC voltage readings at the following test points of circuit #1. Have the instructor check your answers when you have finished.

DC Voltage Check

A. ____________________

B. ____________________

C. ____________________

D. ____________________

E. ____________________

F. ____________________

G. ____________________

H. ____________________

I. ____________________

J. ____________________

Instructor's Initials __________

When you have completed your DC voltage power check, turn off the DC voltage switch on your test board. Turn off the power bench's trainer power panel switch and the 28V DC power switch.

Now you are ready to take AC voltage readings. As you complete each of the following steps place a check on the blank by the number of the step. Note the only difference in reading AC from DC voltage, is that the meter's polarity switch is placed in the AC position.

_____ 1. Turn the RANGE switch of your PSM-37 to the 1000 position.

_____ 2. Turn the POLARITY switch of your PSM-37 to the AC position.

_____ 3. Push in TRAINER POWER PANEL SWITCH and 295V AC 60 Hz POWER PANEL SWITCH circuit breakers.

_____ 4. Place both the TRAINER POWER PANEL SWITCH and the 295V AC 60 Hz POWER PANEL SWITCH to the "ON" position.

_____ 5. Place the AC VOLTAGE SWITCH on the voltage, current, and resistance readings test board (circuit #2) to the "ON" position.

Frame 37

Take AC voltage readings at the following test points of circuit #2. Be sure to work down to the most accurate range. Have the instructor check your answers when you have finished.

AC VOLTAGE CHECK

A. ____________________ F. ____________________

B. ____________________ G. ____________________

C. ____________________ H. ____________________

D. ____________________ I. ____________________

E. ____________________ J. ____________________

Instructor's Initials ______________

When you have completed your AC voltage power check, turn off the AC voltage switch on your test board. Turn off the power bench's power panel switch and 295V AC 60 Hz power panel switch.

Frame 38

In this frame you will prepare your meter to read current.

_____1. Turn the range switch of your PSM-37 to the 1000 position.

_____2. Turn the polarity switch of your PSM-37 to the DC+ position.

_____3. Turn the function switch to the amps/pulse MA position.

_____4. Push in the TRAINER POWER PANEL SWITCH and 28V DC POWER PANEL SWITCH circuit breakers.

_____5. Turn both the TRAINER POWER PANEL SWITCH and the 28V DC POWER PANEL SWITCH on the power bench to the "ON" position.

_____6. Place the DC milliamps switch on the test board to the "ON" position.

Frame 39

Take DC current readings at the following test points of circuit #3. Be sure to start on the 1000 range and work down to the most accurate range for each test point. Have the instructor check your answers when you have finished.

DC Current Check

A. ______________________ ma

B. ______________________ ma

C. ______________________ ma

D. ______________________ ma

E. ______________________ ma

F. ______________________ ma

G. ______________________ ma

H. ______________________ ma

I. ______________________ ma

J. ______________________ ma

Instructor's Initials ______________

When you have completed your DC current check, turn off the DC milliamps switch on the test board. Turn off the power bench's power panel switch and 28VDC power switch. Insure you pull out all circuit breakers.

As you complete each of the following steps place a check on the blank by the number of the step.

_____1. DISCONNECT the DC power cord and the AC power cord, and put them in the power bench's drawer.

_____2. Turn the POLARITY switch on your PSM-37 to the "OFF" position.

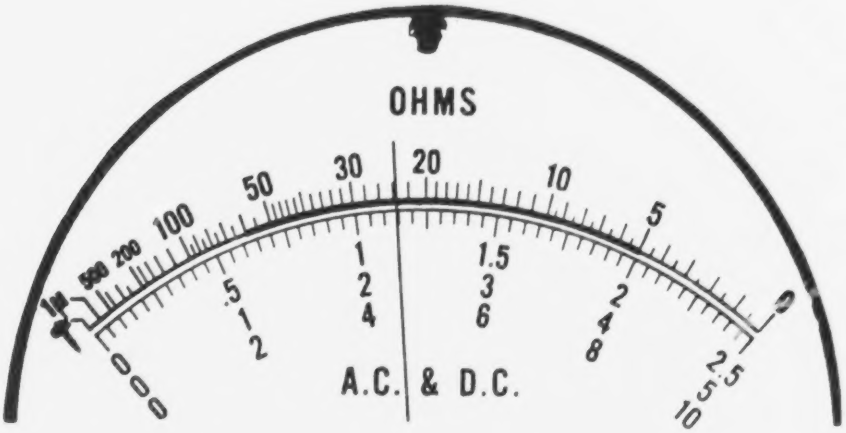
Frame 41

Now that you've successfully passed your practice problems you will be given several problems for review. On voltage, current and resistance readings.

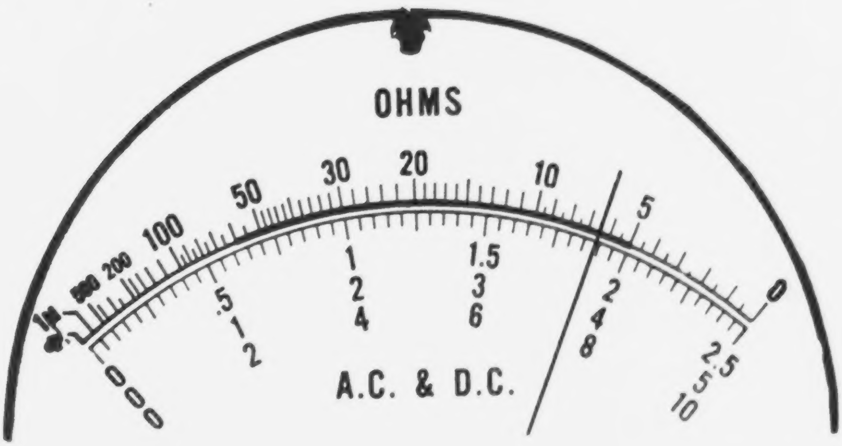
This frame gives values that are to be measured. You will provide the positions of the POLARITY, FUNCTION, and RANGE switches, plus the scale and the group of digits that will be used to make the proper reading. Record this information on the blank spaces. You may use your meter as a reference.

TO MEASURE	FUNCTION	RANGE	POLARITY	SCALE/GROUP
1. 230 Volts AC	VOLTS	250	AC	AC & DC/0-2.5
2. 1500 ohms				/
3. 225 Volts DC				/
4. 22 MA DC				/
5. 290 Volts AC				/
6. .43 Volts DC				/
7. 27,000 ohms				/
8. 17 ohms				/
9. 980 MA AC				/
10. 1.9 Volts AC				/
11. 9 MA DC				/
12. 6 ohms				/

Turn to the next page for instructions.


OHMS
1M
500
200
100
50
30
20
10
5
0
.5
1
2
1
2
4
1.5
3
6
2
4
8
2.5
5
10
0
0
0
A.C. & D.C.

Meter #1.


OHMS
1M
500
200
100
50
30
20
10
5
0
.5
1
2
1
2
4
1.5
3
6
2
4
8
2.5
5
10
0
0
0
A.C. & D.C.

Meter #2.

Frame 42 (Cont'd)

Fill in the blanks with the proper meter readings. Be sure to use the meter referred to on the previous page for each of the control settings. PLUS, indicate in your answer if the value is V DC, V AC, MA DC, MA AC, or Ω.

	METER NUMBER	FUNCTION Sw SETTING	RANGE Sw SETTING	POLARITY Sw SETTING	PROPER READING
1.	1	VOLTS	50	DC+	23V DC
2.	2	VOLTS	250	AC	__________
3.	2	OHMS-STD	R X 100	DC+	__________
4.	1	VOLTS	10	AC	__________
5.	2	VOLTS	.5	AC	__________
6.	1	OHMS-STD	R X 1K	DC+	__________
7.	1	AMPS-MA	50	AC	__________
8.	2	VOLTS	2.5	AC	__________
9.	1	OHMS-LP	R X 1	DC+	__________
10.	2	AMPS-MA	10	AC	__________
11.	2	OHMS-STD	R X 10	DC+	__________
12.	1	AMPS-MA	250	DC+	__________

Answers to Frame 41:

1.	VOLTS	250	AC	AC & DC/0-2.5
2.	OHMS-STD	R X 100	DC+	OHMS/0-∞
3.	VOLTS	250	DC+	AC & DC/0-2.5
4.	AMPS-MA	50	DC+	AC & DC/0-5
5.	VOLTS	500	AC	AC & DC/0-5
6.	VOLTS	.5	DC+	AC & DC/0-5
7.	OHMS-STD	R X 1K	DC+	OHMS/0-∞
8.	OHMS-LP	R X 1	DC+	OHMS/0-∞
9.	AMPS-MA	1000	AC	AC & DC/0-10
10.	VOLTS	2.5	AC	AC & DC/0-2.5
11.	AMPS-MA	10	DC+	AC & DC/0-10
12.	OHMS-LP	R X 1	DC+	OHMS/0-∞

Answers to Frame 42:

1. 23V DC
2. 190V AC
3. 650 Ω
4. 4.6V AC
5. .38 AC
6. 24,000 Ω
7. 23 MA AC
8. 1.9V AC
9. 24 Ω
10. 7.6 MA AC
11. 65 Ω
12. 115 MA DC

If you have made any errors in the last two frames, review the frame(s) of this PT where this information was covered. If you still have difficulty, ask your instructor for assistance.

If you have successfully completed this PT, report to your instructor and he will assign you your progress check.

Environmental Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-WB-112
1 February 1984

USING A MULTIMETER

OBJECTIVES

Before you actually practice using a multimeter, you need to review some important facts pertaining to multimeters.

1. The PSM-37 should never be handled carelessly; aside from being expensive, it is sensitive and delicate. Don't abuse it.

2. Never connect the ohmmeter to a circuit that has power on it.

3. Periodically check the strength of the internal battery. Accomplish this by zeroing the ohmmeter on each of the range switch settings. If it does not zero on all settings, the battery needs to be replaced.

Exercise 1

You are now ready to take resistance readings on the trainer with the PSM-37. As you complete each of the following steps, place a check by the number of the step. Have your instructor help you with steps 1 and 2. Ask for help at any time in this workbook.

_____1. Place your PSM-37 on your assigned power bench.

_____2. Obtain a voltage, current and resistance readings trainer from the storage cabinet and place it on the power bench.

_____3. Set up your PSM-37 for reading ohms. The POLARITY switch should be set at DC+, the FUNCTION switch should be set on OHMS STD and the RANGE switch should be set on the highest ohms setting and work your way down until your needle falls into the bold green area (5-60) on the ohms scale.

_____4. Be sure your meter is zeroed.

_____5. Place one of your leads on TP-13 and the other on TP-14. The polarity doesn't make any difference when reading the resistance of a resistor. (TP means test point.)

_____6. The resistance indicated on your meter is __________ ohms.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 150; DAV - 1

Designed for ATC Course Ise. Do Not Use on the Job.

Exercise 1 (Continued)

While completing this exercise, you will get practice reading resistance with the ohms function of the PSM-37. Remember to set the range switch to a position where the needle rests in the wide green area of the ohms scale before taking your readings. Be sure to zero your meter before starting. When you have completed the following problems report to the instructor.

For each of the following pairs of test points, indicate on the blank the amount of resistance your meter is indicating.

TP	READING
3 & 4	________________
5 & 6	________________
11 & 12	________________
17 & 18	________________
23 & 24	________________
25 & 26	________________
29 & 30	________________
33 & 34	________________
37 & 38	________________

STOP! Do not proceed past this point! See your instructor at this time.

Exercise 2

Before we begin to take some voltage and current readings using the multimeter, let's observe some safety precautions.

1. When measuring unknown voltages and currents, start your check with the RANGE switch set on "1000." Then turn it to a lower setting if necessary. Then return it to the "1000" range. This way the meter will be ready for the next check.

2. When used as a voltmeter, connect it in "parallel" with the voltage drop being checked.

3. When measuring DC voltage and DC durrent, be sure to observe polarity when connecting the meter to the circuit. Note if the meter needle moves left on the scale, either reverse meter nearest on the circuit or turn the polarity switch to the other DC position.

Exercise 2 (Continued)

As you complete this exercise, you will use the PSM-37 to take actual readings. As you complete each of the following steps, place a check on the blank by the number of the step.

_____ 1. Place your PSM-37 and this PT on any available power bench.

_____ 2. Obtain a voltage, current, and resistance readings test board from the storage cabinet and place it on your power bench.

_____ 3. Be sure that the three circuit switches on the voltage, current, and resistance readings test board are in the "OFF" position.

_____ 4. Be sure that the three switches on the power bench are in the "OFF" position.

_____ 5. Place the power bench's DC RANGE SWITCH to the 24V position.

_____ 6. Connect one end of the DC power cord to the voltage, current, and resistance readings test board and the other end to one of the DC outlets on the power bench. The DC power cord is kept in the drawer. Also connect the AC power cord the same manner.

_____ 7. Be sure that the AC and DC both rotary switches mounted on the back of the voltage, current, and resistance readings test board are in the number 1 position.

_____ 8. Place your PSM-37 on the top of the power bench.

_____ 9. Place your meter leads in the test jacks of your meter.

_____10. Place the black lead of your PSM-37 into the GROUND jack (at center) of the voltage, current, and resistance readings test board.

_____11. Set the polarity switch of your PSM-37 to DC+.

_____12. Set the FUNCTION switch of your PSM-37 to the V-1KΩ/V position.

_____13. Since you set the DC RANGE SWITCH on the power bench to 24V, you will not have a reading higher than 24V. Thus, you can safely start on the 50V range of your PSM-37. Set the RANGE switch of your PSM-37 to the 50 position.

_____14. Push in the power bench's TRAINER POWER PANEL SWITCH and 28V DC POWER PANEL SWITCH circuit breakers.

_____15. Place both the TRAINER POWER SWITCH and the 28V DC POWER PANEL SWITCH on the power bench to the ON position.

_____16. Place the DC VOLTAGE SWITCH on the voltage, current, and resistance readings test board the "ON" position. This is circuit #1.

Exercise 2 (Continued)

_____17. Touch the probe of the positive lead to test point A (TP-A) in circuit 1. Be sure that your fingers do not touch the metal probes when taking readings.

_____18. You should notice a very small deflection on your meter. Since your meter is reading less than 10V, you can safely set the RANGE switch of your PSM-37 to the 10 position. Set the RANGE switch of your PSM-37 to the 10 position.

_____19. Your PSM-37 should be indicating approximately 1V. Since this reading is less than 2.5V, you should use the 2.5 range to get the most accurate reading. Set the RANGE switch of your PSM-37 to the 2.5 position.

_____20. What is the PSM-37 reading now? ______________ It should read approximately 1.15.

Take DC voltage readings at the following test points of circuit #1. Have the instructor check your answers when you have finished.

DC VOLTAGE CHECK

A. ______________________________

B. ______________________________

C. ______________________________

D. ______________________________

E. ______________________________

F. ______________________________

G. ______________________________

H. ______________________________

I. ______________________________

J. ______________________________

Instructor's Initials ________________

When you have completed your DC voltage power check, turn off the DC voltage switch on your test board. Turn off the power bench's trainer power panel switch and the 28V DC power switch.

Exercise 2 (Continued)

Now you are ready to take AC voltage readings. As you complete each of the following steps, place a check on the blank by the number of the step. Note the only difference in reading AC from DC voltage, is that the meter's polarity switch is placed in the AC position.

_____1. Turn the RANGE switch of your PSM-37 to the 1000 position.

_____2. Turn the POLARITY switch of your PSM-37 to the AC position.

_____3. Push in TRAINER POWER PANEL SWITCH and 295V AC 60 Hz POWER PANEL SWITCH circuit breakers.

_____4. Place both the TRAINER POWER PANEL SWITCH and the 295V AC 60 Hz POWER PANEL SWITCH to the "ON" position.

_____5. Place the AC VOLTAGE SWITCH on the voltage, current, and resistance readings test board (circuit #2) to the "ON" position.

Take AC voltage readings at the following test points of circuit #2. Be sure to work down to the most accurate range. Have the instructor check your answers when you have finished.

AC VOLTAGE CHECK

A. ______________________________

B. ______________________________

C. ______________________________

D. ______________________________

E. ______________________________

F. ______________________________

G. ______________________________

H. ______________________________

I. ______________________________

J. ______________________________

When you have completed your AC voltage power check, turn off the AC voltage switch on your test board. Turn off the power bench's power panel switch and 295V AC 60 Hz power panel switch.

STOP! Do not proceed past this point! See your instructor at this time.

Exercise 3

In this exercise, you will prepare your meter to read current.

_____1. Turn the range switch of your PSM-37 to the 1000 position.

_____2. Turn the polarity switch of your PSM-37 to the DC+ position.

_____3. Turn the function switch to the amps/pulse MA position.

_____4. Push in the TRAINER POWER PANEL SWITCH and 28V DC POWER PANEL SWITCH circuit breakers.

_____5. Turn both the TRAINER POWER PANEL SWITCH and the 28V DC POWER PANEL SWITCH on the power bench to the "ON" position.

_____6. Place the DC milliamps switch on the test board to the "ON" position.

Take DC current readings at the following test points of circuit #3. Be sure to start on the 1000 range and work down to the most accurate range for each test point. Have the instructor check your answers when you have finished.

DC CURRENT CHECK

A. ______________________________ma

B. ______________________________ma

C. ______________________________ma

D. ______________________________ma

E. ______________________________ma

F. ______________________________ma

G. ______________________________ma

H. ______________________________ma

I. ______________________________ma

J. ______________________________ma

When you have completed your DC current check, turn off the DC milliamps switch on the test board. Turn off the power bench's power panel switch and 28V DC power switch. Insure you pull out all circuit breakers.

As you complete each of the following steps, place a check on the blank by the number of the step.

_____1. DISCONNECT the DC power cord and the AC power cord, and put them in the power bench's drawer.

_____2. Turn the POLARITY switch on your PSM-37 to the "OFF" position.

SEE YOUR INSTRUCTOR AT THIS TIME, YOU ARE NOW READY FOR THE PROGRESS CHECK.

Environmental Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-WB-112
1 February 1984

USING A MULTIMETER

OBJECTIVES

Before you actually practice using a multimeter, you need to review some important facts pertaining to multimeters.

1. The PSM-37 should never be handled carelessly; aside from being expensive, it is sensitive and delicate. Don't abuse it.

2. Never connect the ohmmeter to a circuit that has power on it.

3. Periodically check the strength of the internal battery. Accomplish this by zeroing the ohmmeter on each of the range switch settings. If it does not zero on all settings, the battery needs to be replaced.

Exercise 1

You are now ready to take resistance readings on the trainer with the PSM-37. As you complete each of the following steps, place a check by the number of the step. Have your instructor help you with steps 1 and 2. Ask for help at any time in this workbook.

_____1. Place your PSM-37 on your assigned power bench.

_____2. Obtain a voltage, current and resistance readings trainer from the storage cabinet and place it on the power bench.

_____3. Set up your PSM-37 for reading ohms. The POLARITY switch should be set at DC+, the FUNCTION switch should be set on OHMS STD and the RANGE switch should be set on the highest ohms setting and work your way down until your needle falls into the bold green area (5-60) on the ohms scale.

_____4. Be sure your meter is zeroed.

_____5. Place one of your leads on TP-13 and the other on TP-14. The polarity doesn't make any difference when reading the resistance of a resistor. (TP means test point.)

_____6. The resistance indicated on your meter is __________ ohms.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 150; DAV - 1

Designed for ATC Course Ise. Do Not Use on the Job.

Exercise 1 (Continued)

While completing this exercise, you will get practice reading resistance with the ohms function of the PSM-37. Remember to set the range switch to a position where the needle rests in the wide green area of the ohms scale before taking your readings. Be sure to zero your meter before starting. When you have completed the following problems report to the instructor.

For each of the following pairs of test points, indicate on the blank the amount of resistance your meter is indicating.

TP	READING
3 & 4	
5 & 6	
11 & 12	
17 & 18	
23 & 24	
25 & 26	
29 & 30	
33 & 34	
37 & 38	

STOP! Do not proceed past this point! See your instructor at this time.

Exercise 2

Before we begin to take some voltage and current readings using the multimeter, let's observe some safety precautions.

1. When measuring unknown voltages and currents, start your check with the RANGE switch set on "1000." Then turn it to a lower setting if necessary. Then return it to the "1000" range. This way the meter will be ready for the next check.

2. When used as a voltmeter, connect it in "parallel" with the voltage drop being checked.

3. When measuring DC voltage and DC durrent, be sure to observe polarity when connecting the meter to the circuit. Note if the meter needle moves left on the scale, either reverse meter nearest on the circuit or turn the polarity switch to the other DC position.

Exercise 2 (Continued)

As you complete this exercise, you will use the PSM-37 to take actual readings. As you complete each of the following steps, place a check on the blank by the number of the step.

_____ 1. Place your PSM-37 and this PT on any available power bench.

_____ 2. Obtain a voltage, current, and resistance readings test board from the storage cabinet and place it on your power bench.

_____ 3. Be sure that the three circuit switches on the voltage, current, and resistance readings test board are in the "OFF" position.

_____ 4. Be sure that the three switches on the power bench are in the "OFF" position.

_____ 5. Place the power bench's DC RANGE SWITCH to the 24V position.

_____ 6. Connect one end of the DC power cord to the voltage, current, and resistance readings test board and the other end to one of the DC outlets on the power bench. The DC power cord is kept in the drawer. Also connect the AC power cord the same manner.

_____ 7. Be sure that the AC and DC both rotary switches mounted on the back of the voltage, current, and resistance readings test board are in the number 1 position.

_____ 8. Place your PSM-37 on the top of the power bench.

_____ 9. Place your meter leads in the test jacks of your meter.

_____10. Place the black lead of your PSM-37 into the GROUND jack (at center) of the voltage, current, and resistance readings test board.

_____11. Set the polarity switch of your PSM-37 to DC+.

_____12. Set the FUNCTION switch of your PSM-37 to the V-1KΩ/V position.

_____13. Since you set the DC RANGE SWITCH on the power bench to 24V, you will not have a reading higher than 24V. Thus, you can safely start on the 50V range of your PSM-37. Set the RANGE switch of your PSM-37 to the 50 position.

_____14. Push in the power bench's TRAINER POWER PANEL SWITCH and 28V DC POWER PANEL SWITCH circuit breakers.

_____15. Place both the TRAINER POWER SWITCH and the 28V DC POWER PANEL SWITCH on the power bench to the ON position.

_____16. Place the DC VOLTAGE SWITCH on the voltage, current, and resistance readings test board the "ON" position. This is circuit #1.

Exercise 2 (Continued)

_____17. Touch the probe of the positive lead to test point A (TP-A) in circuit 1. Be sure that your fingers do not touch the metal probes when taking readings.

_____18. You should notice a very small deflection on your meter. Since your meter is reading less than 10V, you can safely set the RANGE switch of your PSM-37 to the 10 position. Set the RANGE switch of your PSM-37 to the 10 position.

_____19. Your PSM-37 should be indicating approximately 1V. Since this reading is less than 2.5V, you should use the 2.5 range to get the most accurate reading. Set the RANGE switch of your PSM-37 to the 2.5 position.

_____20. What is the PSM-37 reading now? ______________ It should read approximately 1.15.

Take DC voltage readings at the following test points of circuit #1. Have the instructor check your answers when you have finished.

DC VOLTAGE CHECK

A. ____________________________

B. ____________________________

C. ____________________________

D. ____________________________

E. ____________________________

F. ____________________________

G. ____________________________

H. ____________________________

I. ____________________________

J. ____________________________

Instructor's Initials _______________

When you have completed your DC voltage power check, turn off the DC voltage switch on your test board. Turn off the power bench's trainer power panel switch and the 28V DC power switch.

Exercise 2 (Continued)

Now you are ready to take AC voltage readings. As you complete each of the following steps, place a check on the blank by the number of the step. Note the only difference in reading AC from DC voltage, is that the meter's polarity switch is placed in the AC position.

_____1. Turn the RANGE switch of your PSM-37 to the 1000 position.

_____2. Turn the POLARITY switch of your PSM-37 to the AC position.

_____3. Push in TRAINER POWER PANEL SWITCH and 295V AC 60 Hz POWER PANEL SWITCH circuit breakers.

_____4. Place both the TRAINER POWER PANEL SWITCH and the 295V AC 60 Hz POWER PANEL SWITCH to the "ON" position.

_____5. Place the AC VOLTAGE SWITCH on the voltage, current, and resistance readings test board (circuit #2) to the "ON" position.

Take AC voltage readings at the following test points of circuit #2. Be sure to work down to the most accurate range. Have the instructor check your answers when you have finished.

AC VOLTAGE CHECK

A. ______________________________

B. ______________________________

C. ______________________________

D. ______________________________

E. ______________________________

F. ______________________________

G. ______________________________

H. ______________________________

I. ______________________________

J. ______________________________

When you have completed your AC voltage power check, turn off the AC voltage switch on your test board. Turn off the power bench's power panel switch and 295V AC 60 Hz power panel switch.

STOP! Do not proceed past this point! See your instructor at this time.

Exercise 3

In this exercise, you will prepare your meter to read current.

_____1. Turn the range switch of your PSM-37 to the 1000 position.

_____2. Turn the polarity switch of your PSM-37 to the DC+ position.

_____3. Turn the function switch to the amps/pulse MA position.

_____4. Push in the TRAINER POWER PANEL SWITCH and 28V DC POWER PANEL SWITCH circuit breakers.

_____5. Turn both the TRAINER POWER PANEL SWITCH and the 28V DC POWER PANEL SWITCH on the power bench to the "ON" position.

_____6. Place the DC milliamps switch on the test board to the "ON" position.

Take DC current readings at the following test points of circuit #3. Be sure to start on the 1000 range and work down to the most accurate range for each test point. Have the instructor check your answers when you have finished.

DC CURRENT CHECK

A. ______________________________ ma
B. ______________________________ ma
C. ______________________________ ma
D. ______________________________ ma
E. ______________________________ ma
F. ______________________________ ma
G. ______________________________ ma
H. ______________________________ ma
I. ______________________________ ma
J. ______________________________ ma

When you have completed your DC current check, turn off the DC milliamps switch on the test board. Turn off the power bench's power panel switch and 28V DC power switch. Insure you pull out all circuit breakers.

As you complete each of the following steps, place a check on the blank by the number of the step.

_____1. DISCONNECT the DC power cord and the AC power cord, and put them in the power bench's drawer.

_____2. Turn the POLARITY switch on your PSM-37 to the "OFF" position.

SEE YOUR INSTRUCTOR AT THIS TIME, YOU ARE NOW READY FOR THE PROGRESS CHECK.

DEPARTMENT OF THE AIR FORCE
3330 Technical Training Wing (ATC)
Chanute AFB, Illinois 61868

Service Test
C3ABR42331-HO-113
22 August 1984

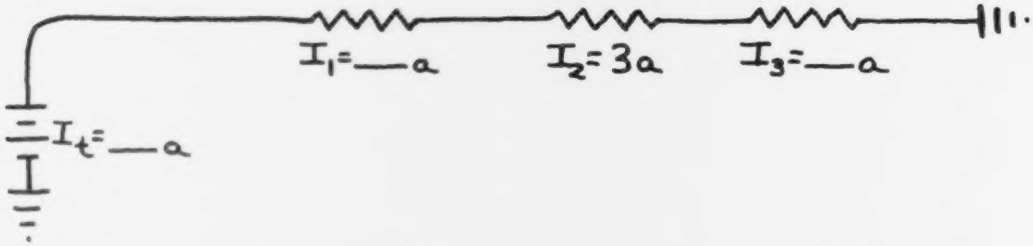
BASIC ELECTRICAL CIRCUITS

INSTRUCTIONS:

Using applicable laws and formulas solve for unknown values in basic electrical circuits:

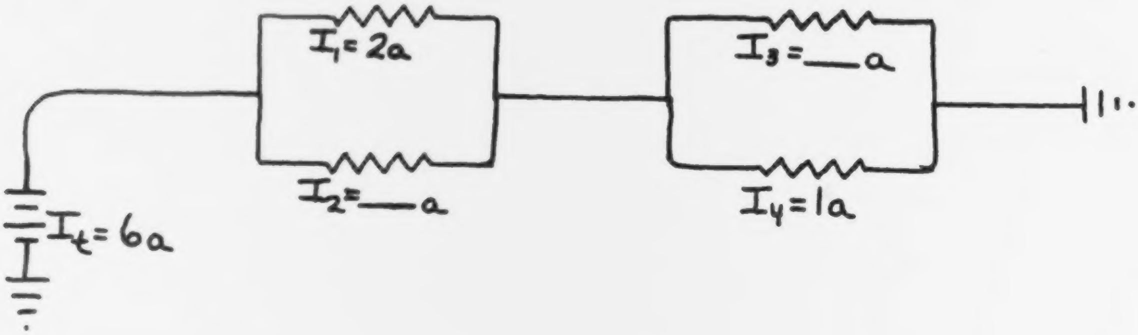
1a. Kirchoff's Current Law

1.



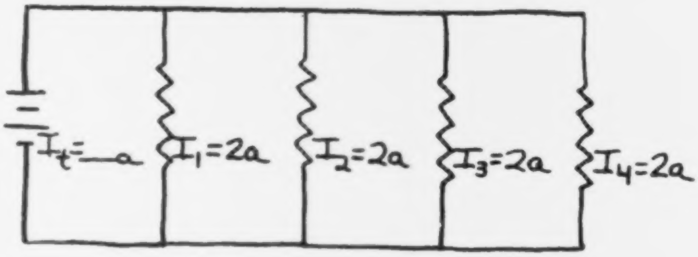
I_1=__a
I_2=3a
I_3=__a
I_t=__a

2.



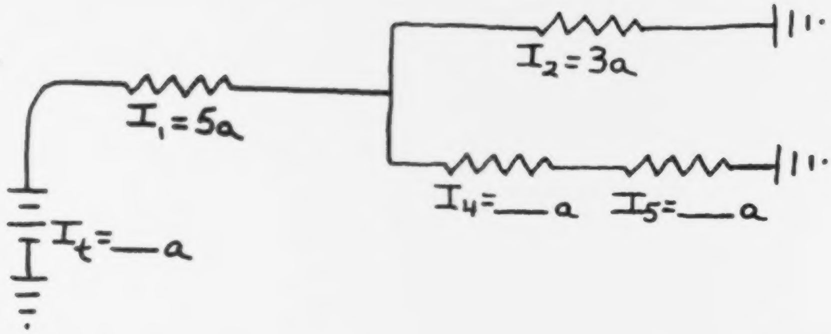
I_1=2a
I_3=__a
I_2=__a
I_4=1a
I_t=6a

3.



I_t=__a
I_1=2a
I_2=2a
I_3=2a
I_4=2a

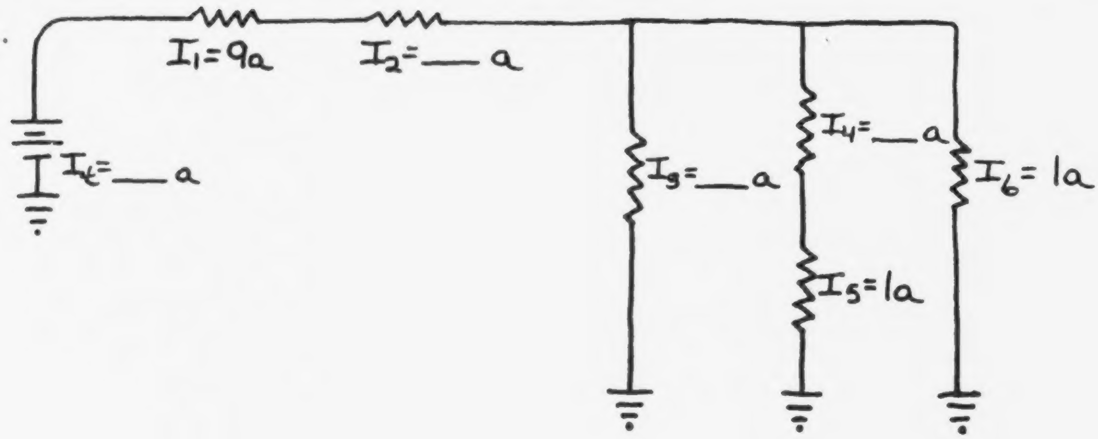
4.



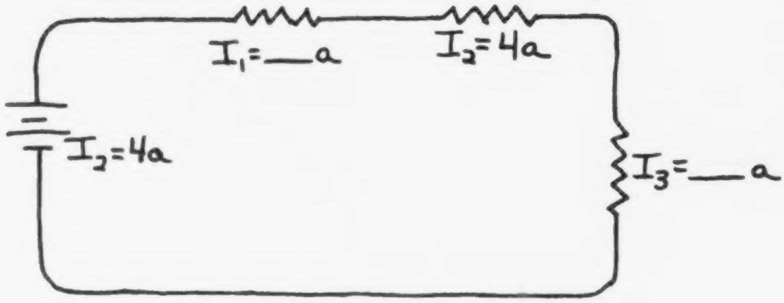
I_2=3a
I_1=5a
I_4=__a
I_5=__a
I_t=__a

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500 -

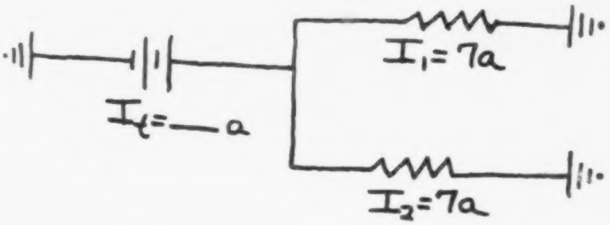
5.


I_1=9a
I_2=___ a
I_t=___ a
I_3=___ a
I_4=___ a
I_6= 1a
I_5=1a

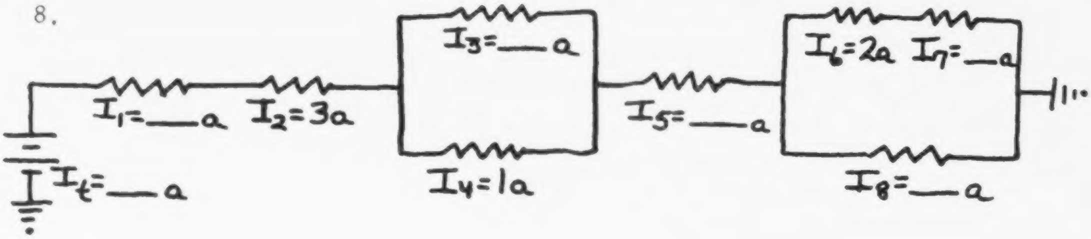
6.


I_1=___ a
I_2=4a
I_2=4a
I_3=___ a

7.

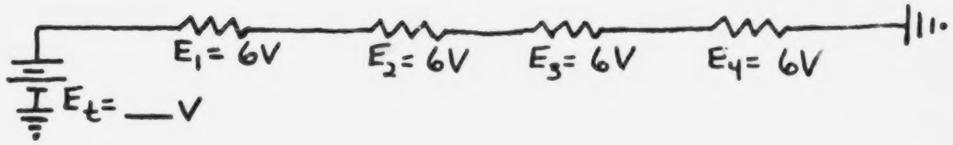

I_1= 7a
I_t=___ a
I_2=7a

8.

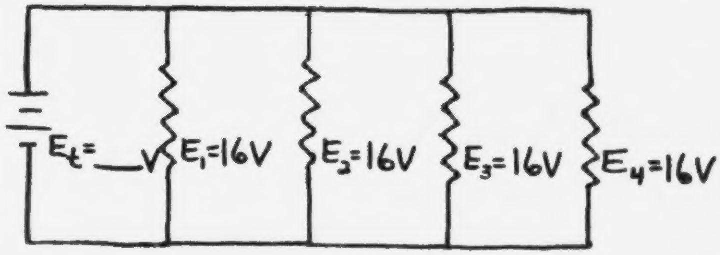

I_3=___ a
I_6=2a
I_7=___ a
I_1=___ a
I_2=3a
I_5=___ a
I_t=___ a
I_4=1a
I_8=___ a

1b. Kirchoff's Voltage Law

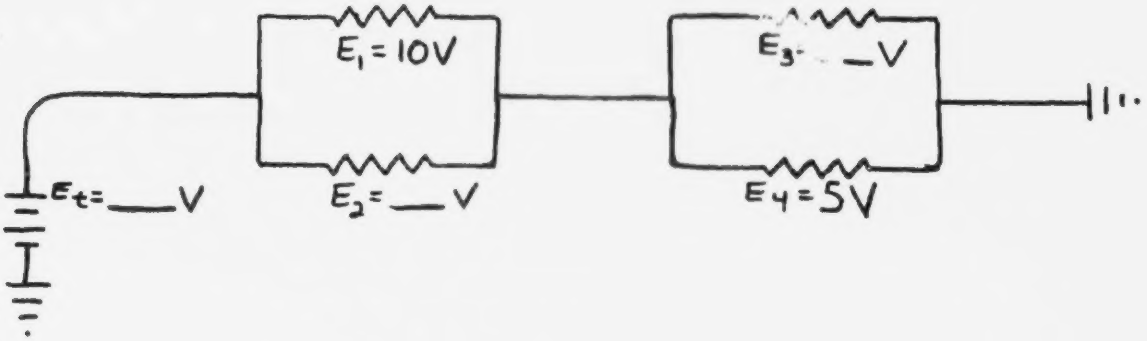
1.


E1 = 6V
E2 = 6V
E3 = 6V
E4 = 6V
Et = __V

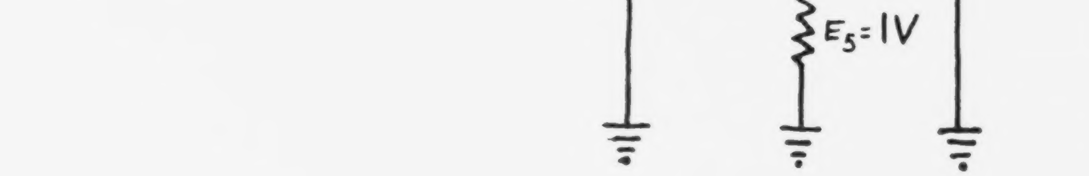
2.


Et = __V
E1 = 16V
E2 = 16V
E3 = 16V
E4 = 16V

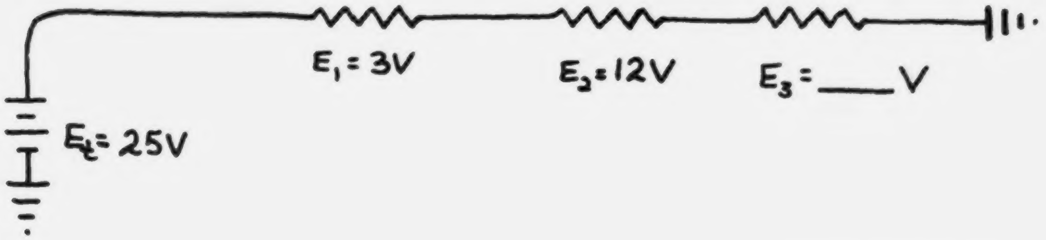
3.


E1 = 10V
E3 = __V
Et = __V
E2 = __V
E4 = 5V

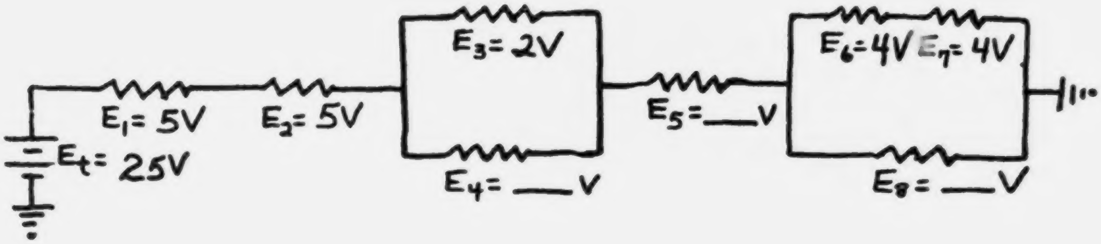
4.


E1 = __V
E2 = 6V
Et = 18V
E3 = __V
E4 = __V
E6 = 4V
E5 = 1V

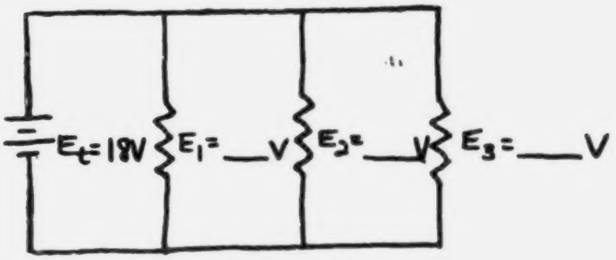
5.


$E_1 = 3V$
$E_2 = 12V$
$E_3 =$ ____ V
$E_t = 25V$

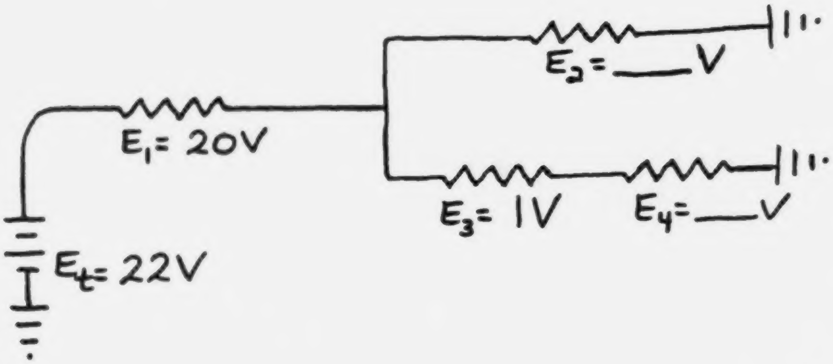
6.


$E_3 = 2V$
$E_6 = 4V$ $E_7 = 4V$
$E_1 = 5V$
$E_2 = 5V$
$E_5 =$ ___ V
$E_t = 25V$
$E_4 =$ ___ V
$E_8 =$ ___ V

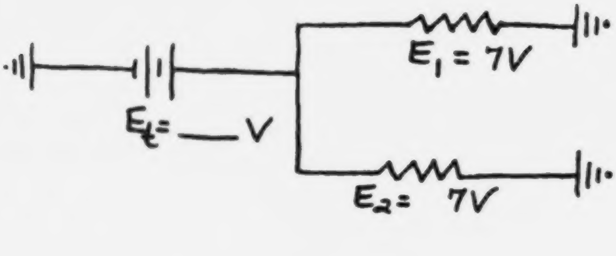
7.


$E_t = 18V$
$E_1 =$ ___ V
$E_2 =$ ___ V
$E_3 =$ ___ V

8.


$E_2 =$ ___ V
$E_1 = 20V$
$E_3 = 1V$
$E_4 =$ ___ V
$E_t = 22V$

9.


$E_1 = 7V$
$E_t =$ ___ V
$E_2 = 7V$

1c. OHM'S LAW

1. E=
I= 3a
R= 6 Ω
P=

2. E= 12v
I= 2a
R=
P=

3. E= 5v
I= 10a
R=
P=

4. E= 6v
I=
R= 12 Ω
P=

5. E= 3v
I=
R=
P= 18w

6. E=
I= 9a
R= 3 Ω
P=

7. E= 12v
I=
R= 120 Ω
P=

8. E=
I= 2a
R=
P= 8w

9. E= 6v
I= 4a
R=
P=

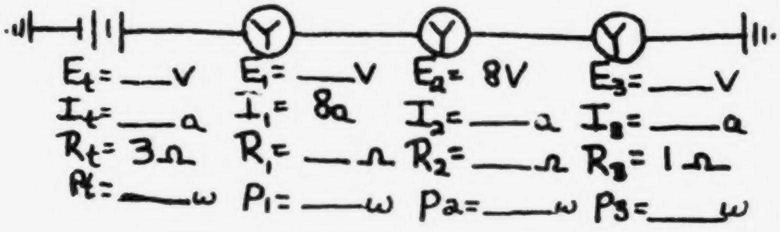
10. E= 24v
I= .2a
R=
P=

11. E= 4v
I= .25a
R=
P=

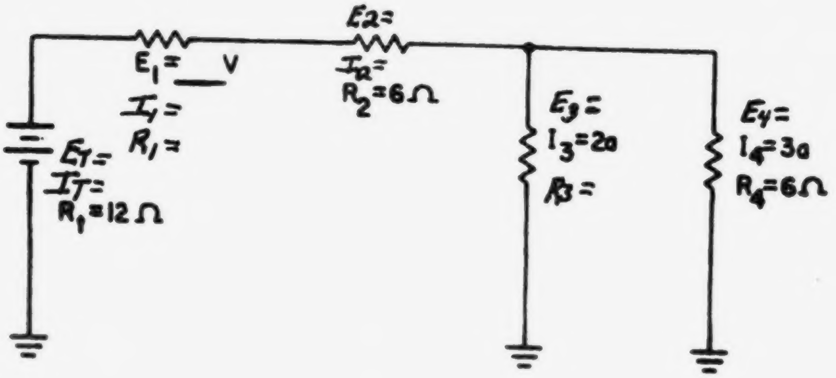
12. E= 1.4v
I=
R= .7 Ω
P=

2a. Circuit Problems

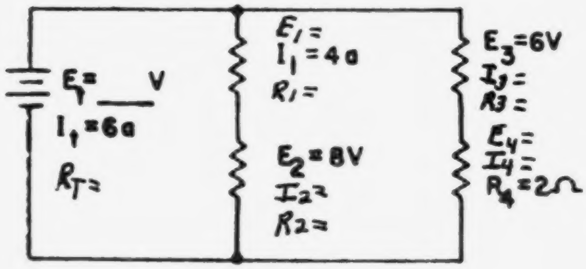
1.


Et= __V
It= __a
Rt= 3Ω
Pt= __ω
E1= __V
I1= 8a
R1= __Ω
P1= __ω
E2= 8V
I2= __a
R2= __Ω
P2= __ω
E3= __V
I3= __a
R3= 1Ω
P3= __ω

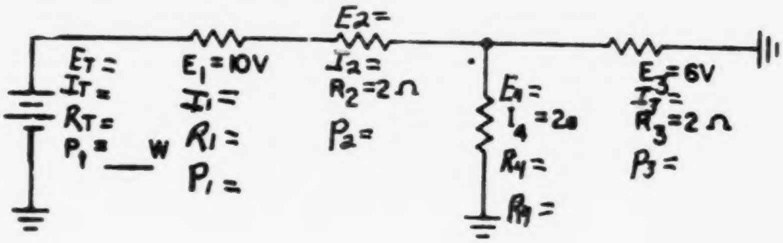
2.


E2=
I2=
R2=6Ω
E1= __V
I1=
R1=
ET=
IT=
Rt=12Ω
E3=
I3=2a
R3=
E4=
I4=3a
R4=6Ω

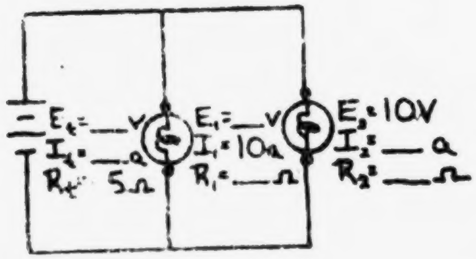
3.


ET= __V
It=6a
RT=
E1=
I1=4a
R1=
E2=8V
I2=
R2=
E3=6V
I3=
R3=
E4=
I4=
R4=2Ω

4.

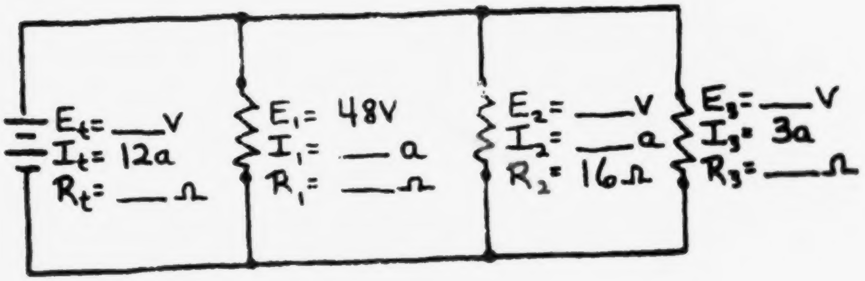

E2=
ET=
IT=
RT=
Pt= __W
E1=10V
I1=
R1=
P1=
I2=
R2=2Ω
P2=
E4=
I4=2a
R4=
P4=
E3=6V
I3=
R3=2Ω
P3=

5.



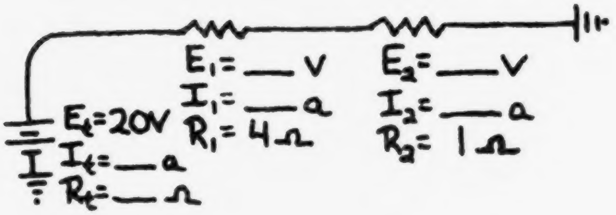
Et= __V
It= __a
Rt= 5Ω
E1= __V
I1= 10a
R1= __Ω
E2= 10V
I2= __a
R2= __Ω

6.



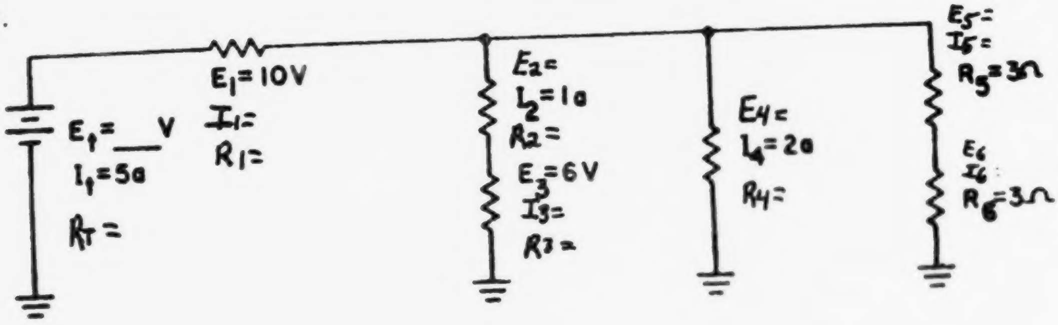
Et= __V
It= 12a
Rt= __Ω
E1= 48V
I1= __a
R1= __Ω
E2= __V
I2= __a
R2= 16Ω
E3= __V
I3= 3a
R3= __Ω

7.



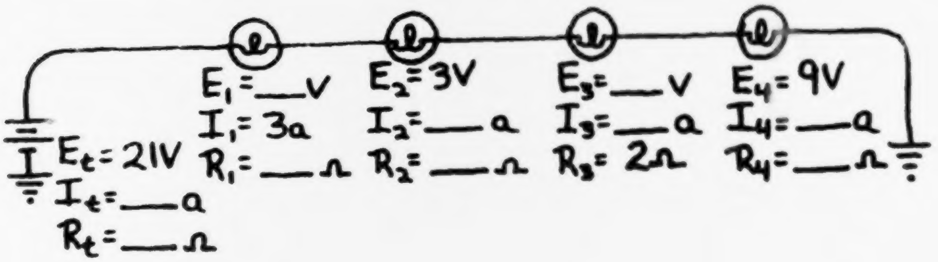
Et=20V
It= __a
Rt= __Ω
E1= __V
I1= __a
R1= 4Ω
E2= __V
I2= __a
R2= 1Ω

8.

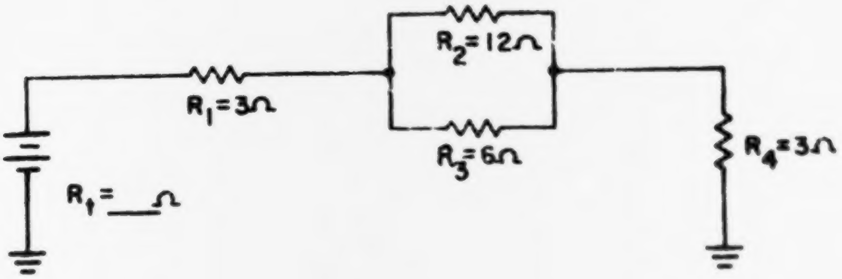


Et= __V
It=5a
RT=
E1=10V
I1=
R1=
E2=
I2=1a
R2=
E3=6V
I3=
R3=
E4=
I4=2a
R4=
E5=
I5=
R5=3Ω
E6
I6
R6=3Ω

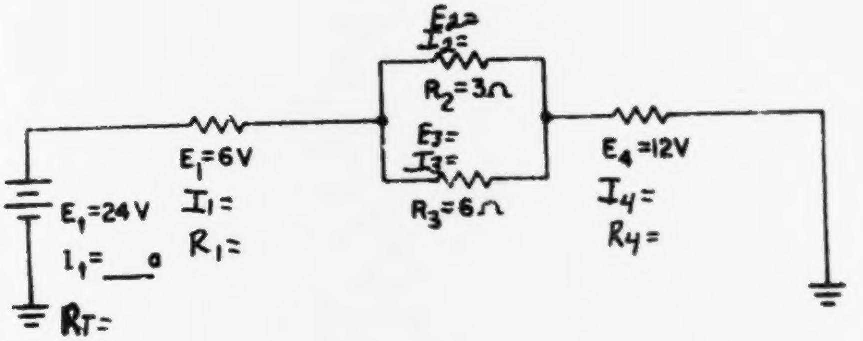
9.


E₁ = ___ V
I₁ = 3a
R₁ = ___ Ω
E₂ = 3V
I₂ = ___ a
R₂ = ___ Ω
E₃ = ___ V
I₃ = ___ a
R₃ = 2Ω
E₄ = 9V
I₄ = ___ a
R₄ = ___ Ω
Eₜ = 21V
Iₜ = ___ a
Rₜ = ___ Ω

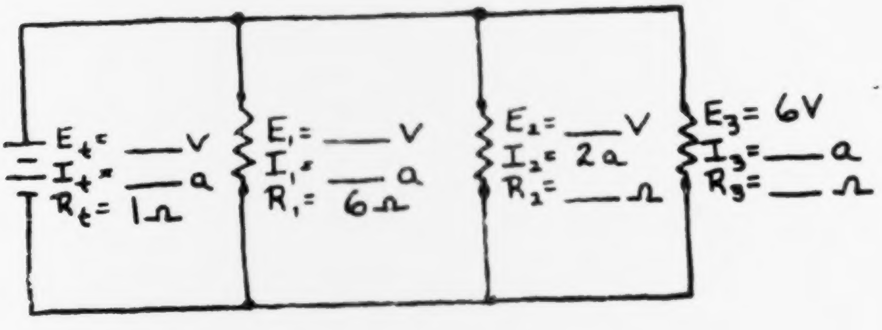
10.


R₁ = 3Ω
R₂ = 12Ω
R₃ = 6Ω
R₄ = 3Ω
Rₜ = ___ Ω

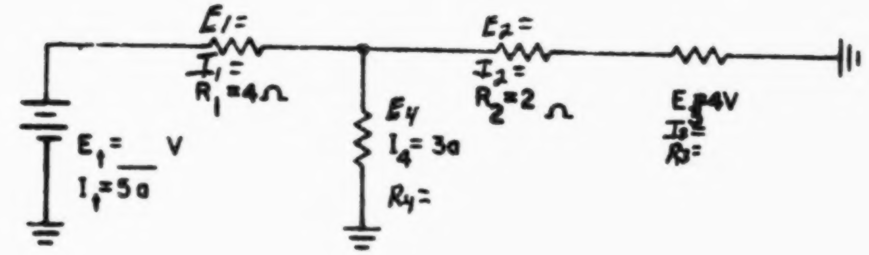
11.


E₂ =
I₂ =
R₂ = 3Ω
E₃ =
I₃ =
R₃ = 6Ω
E₁ = 6V
I₁ =
R₁ =
E₄ = 12V
I₄ =
R₄ =
Eₜ = 24V
Iₜ = ___ a
Rт =

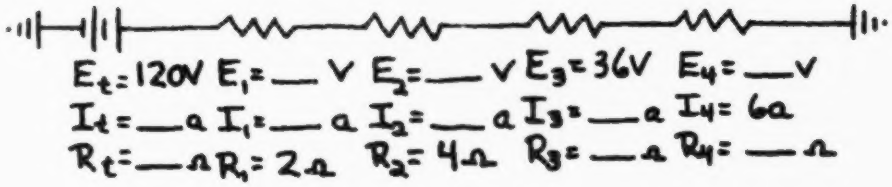
12.


Eₜ = ___ V
Iₜ = ___ a
Rₜ = 1Ω
E₁ = ___ V
I₁ = ___ a
R₁ = 6Ω
E₂ = ___ V
I₂ = 2a
R₂ = ___ Ω
E₃ = 6V
I₃ = ___ a
R₃ = ___ Ω

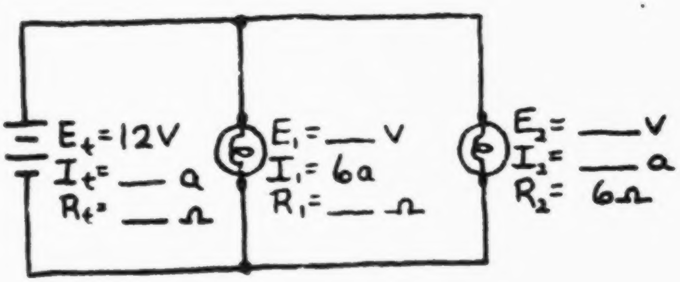
13.


E_1=
I_1=
R_1=4Ω
E_2=
I_2=
R_2=2 Ω
E_3=4V
I_3=
R_3=
E_4
I_4= 3a
R_4=
E_t= __ V
I_t=5a

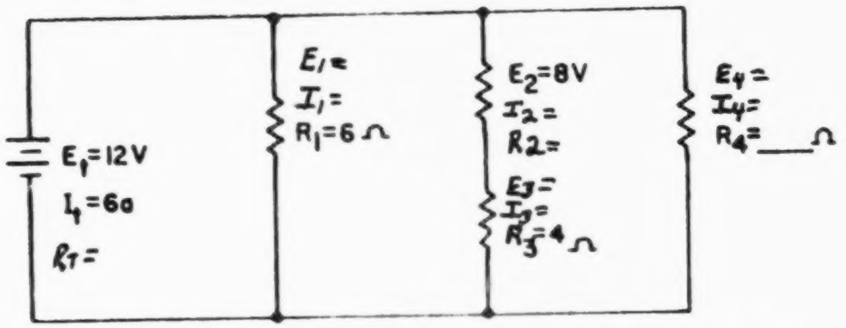
14.


E_t=120V E_1= __ V E_2= __ V E_3=36V E_4= __ V
I_t= __ a I_1= __ a I_2= __ a I_3= __ a I_4= 6a
R_t= __ Ω R_1= 2Ω R_2= 4Ω R_3= __ Ω R_4= __ Ω

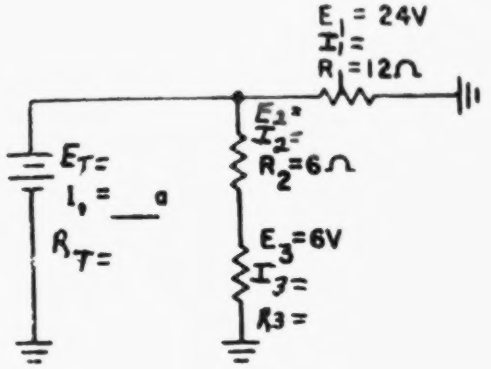
15.


E_t=12V
I_t= __ a
R_t= __ Ω
E_1= __ V
I_1= 6a
R_1= __ Ω
E_2= __ V
I_2= __ a
R_2= 6Ω

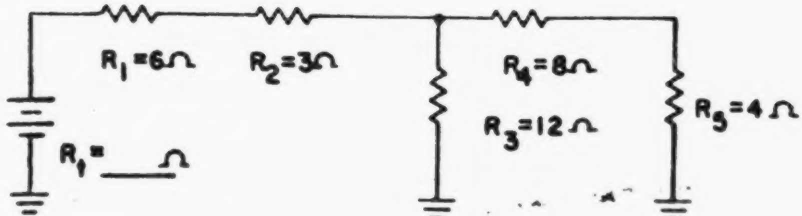
16.


E_t=12V
I_t=6a
R_T=
E_1=
I_1=
R_1=6 Ω
E_2=8V
I_2=
R_2=
E_3=
I_3=
R_3=4 Ω
E_4=
I_4=
R_4= __ Ω

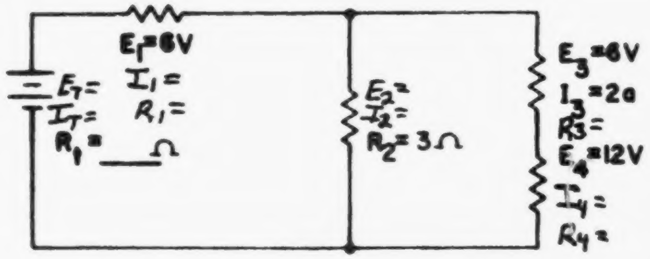
17.


$E_1 = 24V$
$I_1 =$
$R_1 = 12\Omega$
$E_T =$
$I_t =$ ___ a
$R_T =$
$E_2 =$
$I_2 =$
$R_2 = 6\Omega$
$E_3 = 6V$
$I_3 =$
$R_3 =$

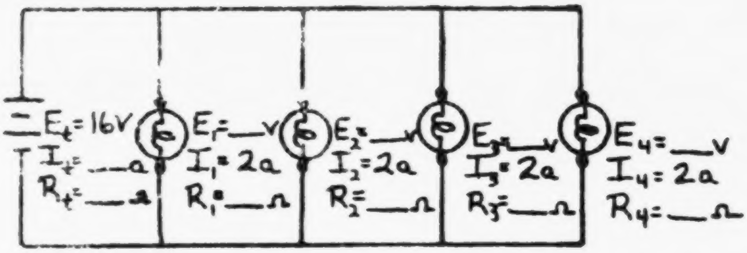
18.


$R_1 = 6\Omega$
$R_2 = 3\Omega$
$R_4 = 8\Omega$
$R_3 = 12\Omega$
$R_5 = 4\Omega$
$R_t =$ ___ Ω

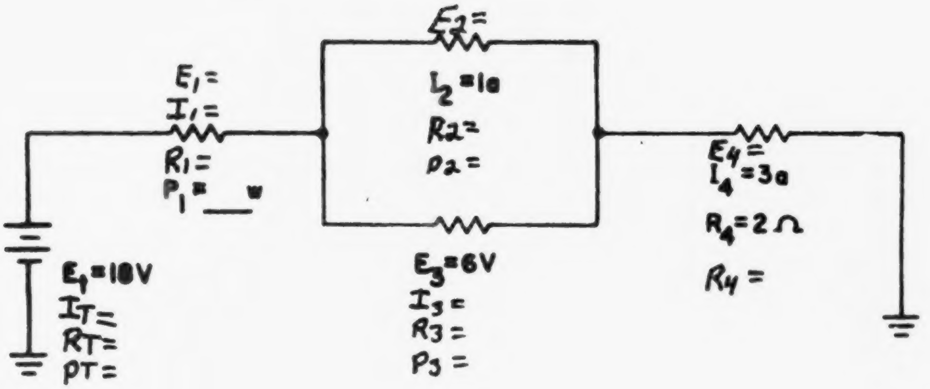
19.


$E_1 = 6V$
$I_1 =$
$R_1 =$
$E_T =$
$I_T =$
$R_t =$ ___ Ω
$E_2 =$
$I_2 =$
$R_2 = 3\Omega$
$E_3 = 6V$
$I_3 = 2a$
$R_3 =$
$E_4 = 12V$
$I_4 =$
$R_4 =$

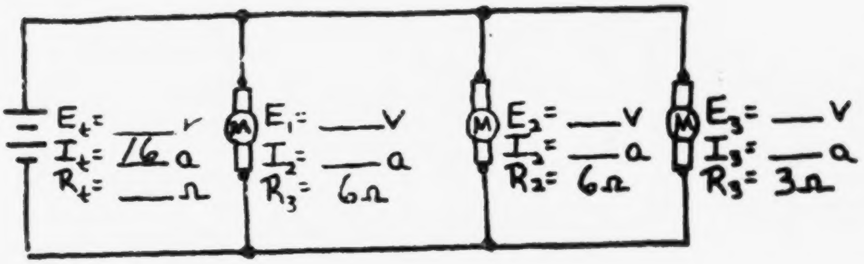
20.


$E_t = 16V$
$I_t =$ ___ a
$R_t =$ ___ a
$E_1 =$ ___ v
$I_1 = 2a$
$R_1 =$ ___ Ω
$E_2 =$ ___ v
$I_2 = 2a$
$R_2 =$ ___ Ω
$E_3 =$ ___ v
$I_3 = 2a$
$R_3 =$ ___ Ω
$E_4 =$ ___ v
$I_4 = 2a$
$R_4 =$ ___ Ω

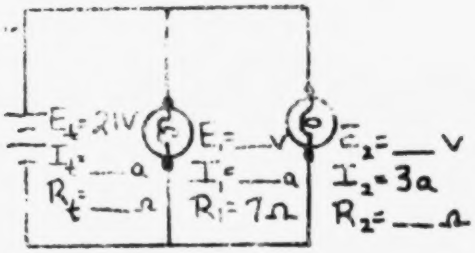
21.


E2=
E1=
I1=
R1=
P1= ___ w
I2=1a
R2=
P2=
E4=
I4=3a
R4=2Ω
R4=
E3=6V
I3=
R3=
P3=
ET=18V
IT=
RT=
PT=

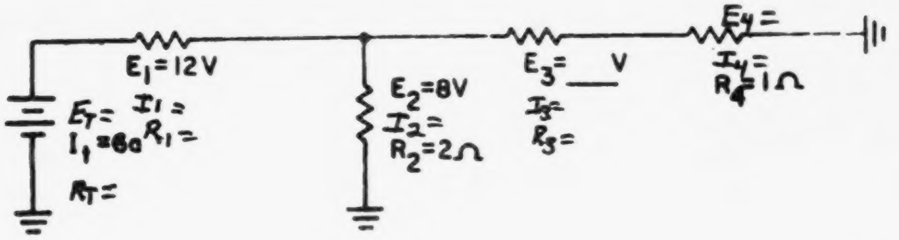
22.


Et= ___ v
It= 16 a
Rt= ___ Ω
M
E1= ___ V
I2= ___ a
R3= 6Ω
M
E2= ___ V
I2= ___ a
R2= 6Ω
M
E3= ___ V
I3= ___ a
R3= 3Ω

23.


Et=21V
It= ___ a
Rt= ___ Ω
E1= ___ V
I1= ___ a
R1= 7Ω
E2= ___ V
I2= 3a
R2= ___ Ω

24.


E1=12V
ET=
I1=
I1=6a
R1=
RT=
E2=8V
I2=
R2=2Ω
E3= ___ V
I3=
R3=
E4=
I4=
R4=1Ω

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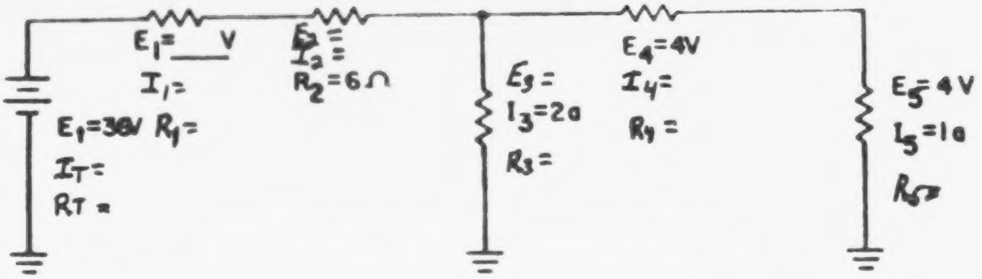
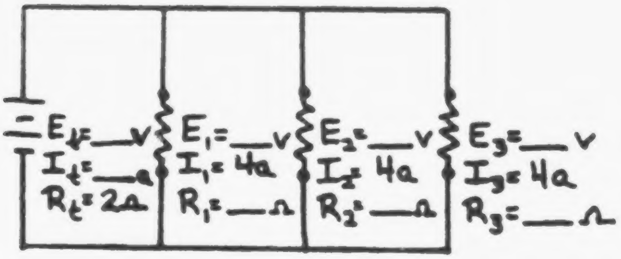
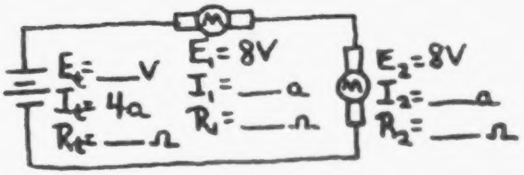
25.


E1= ___ V
I1=
E2=
I2=
R2=6Ω
Et=36V R1=
IT=
RT=
E3=
I3=2a
R3=
E4=4V
I4=
R4=
E5=4V
I5=1a
R5=

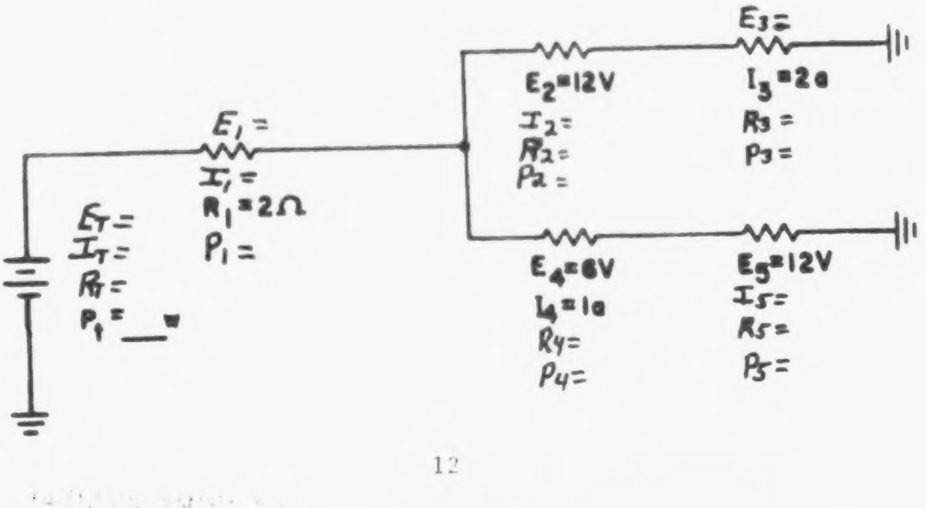
26.


Et= ___ v
It= ___ a
Rt= 2Ω
E1= ___ v
I1= 4a
R1= ___ Ω
E2= ___ v
I2= 4a
R2= ___ Ω
E3= ___ v
I3= 4a
R3= ___ Ω

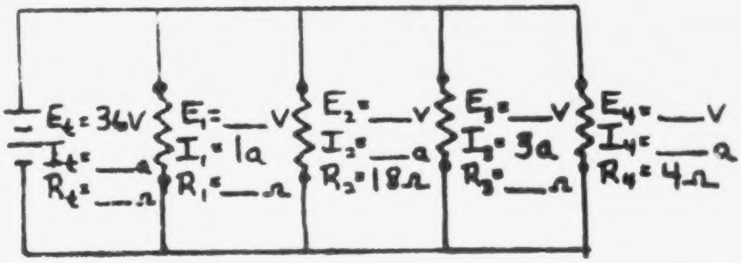
27.


M
Et= ___ V
It= 4a
Rt= ___ Ω
E1= 8V
I1= ___ a
R1= ___ Ω
M
E2= 8V
I2= ___ a
R2= ___ Ω

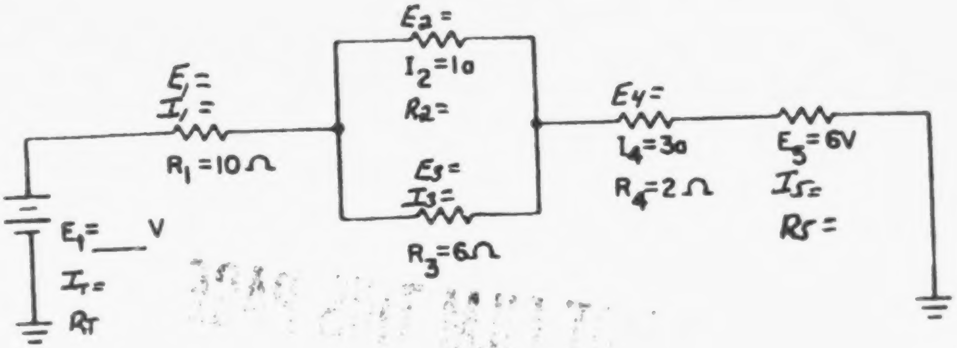
28.


E1 =
I1 =
R1 = 2Ω
P1 =
ET =
IT =
RT =
Pt = ___ w
E2=12V
I2=
R2=
P2 =
E3=
I3=2a
R3 =
P3 =
E4=6V
I4=1a
R4=
P4=
E5=12V
I5=
R5=
P5=

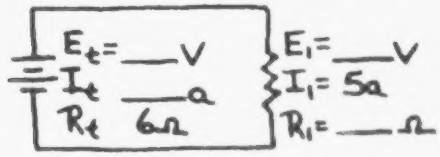
29.


E_t = 36V
I_t = ___ a
R_t = ___ Ω
E_1 = ___ V
I_1 = 1a
R_1 = ___ Ω
E_2 = ___ V
I_2 = ___ a
R_2 = 18Ω
E_3 = ___ V
I_3 = 3a
R_3 = ___ Ω
E_4 = ___ V
I_4 = ___ a
R_4 = 4Ω

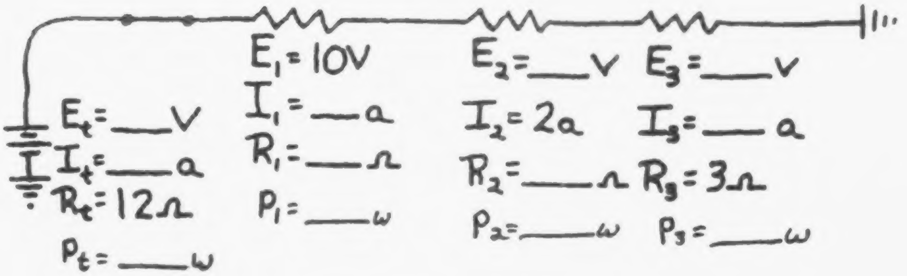
30.


E_1 =
I_1 =
R_1 = 10Ω
E_2 =
I_2 = 1a
R_2 =
E_3 =
I_3 =
R_3 = 6Ω
E_4 =
I_4 = 3a
R_4 = 2Ω
E_5 = 6V
I_5 =
R_5 =
E_T = ___ V
I_T =
R_T

31.


E_t = ___ V
I_t ___ a
R_t 6Ω
E_1 = ___ V
I_1 = 5a
R_1 = ___ Ω

32.


E_t = ___ V
I_t = ___ a
R_t = 12Ω
P_t = ___ ω
E_1 = 10V
I_1 = ___ a
R_1 = ___ Ω
P_1 = ___ ω
E_2 = ___ V
I_2 = 2a
R_2 = ___ Ω
P_2 = ___ ω
E_3 = ___ V
I_3 = ___ a
R_3 = 3Ω
P_3 = ___ ω

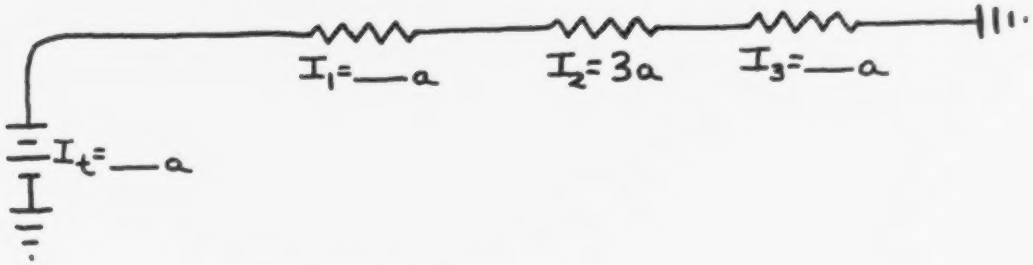
Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-HO-113A
23 May 1984

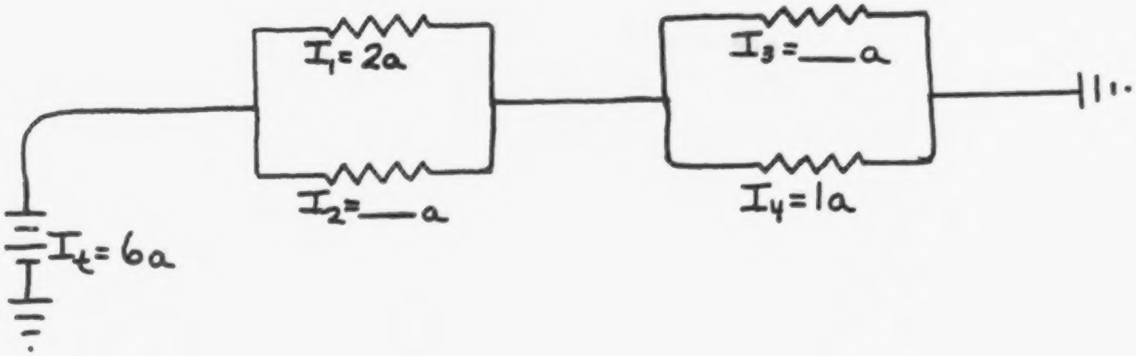
KIRCHHOFF'S CURRENT LAW

INSTRUCTIONS: Using Kirchhoff's Current Law, solve for the unknown values(s).

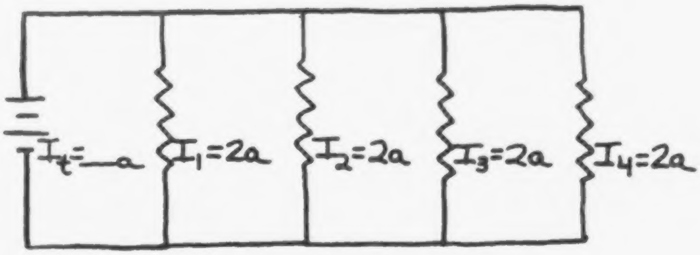
1.


I_1=__a
I_2= 3a
I_3=__a
I_t=__a

2.


I_1= 2a
I_3=__a
I_2=__a
I_4=1a
I_t= 6a

3.


I_t=__a
I_1=2a
I_2=2a
I_3=2a
I_4=2a

Supersedes C3ABR42331-HO-114, 10 January 1984
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 250; DAV - 1

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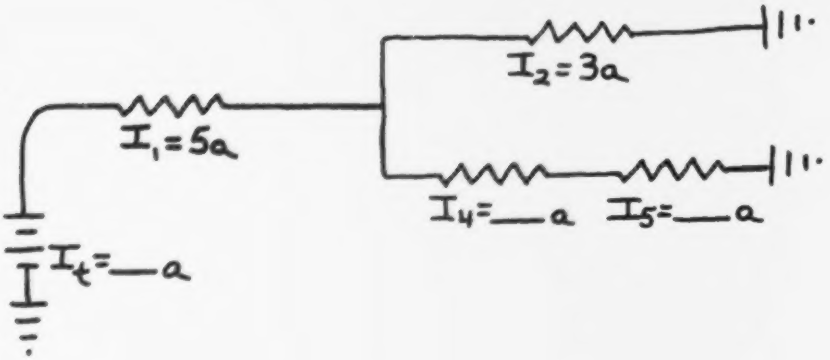
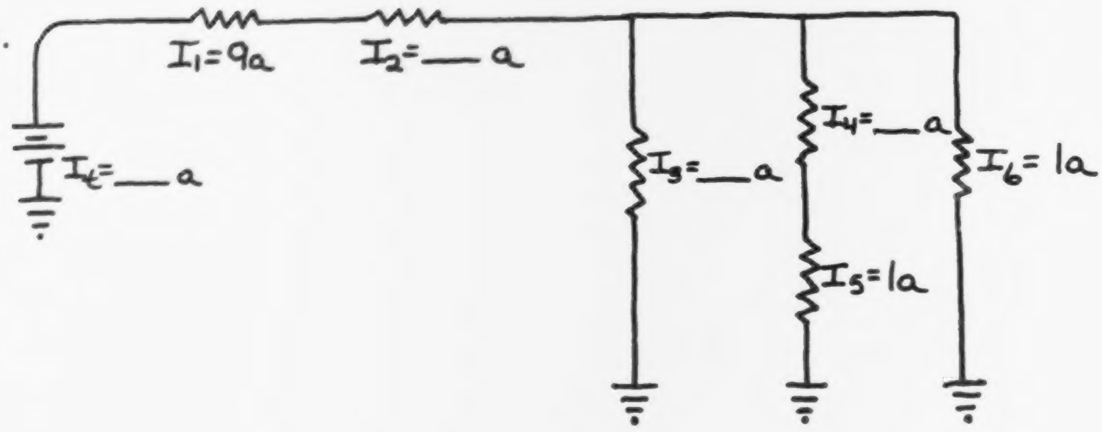
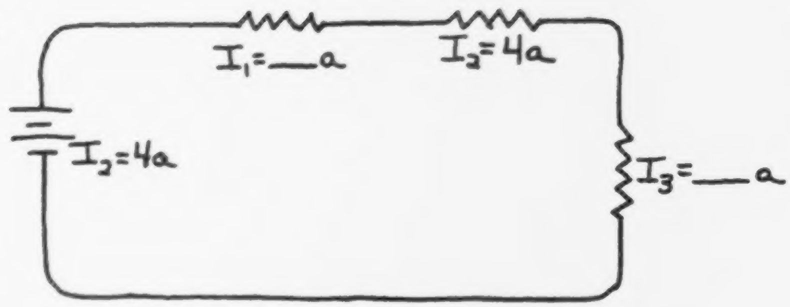
4.


I₂ = 3a
I₁ = 5a
I₄ = __ a
I₅ = __ a
Iₜ = __ a

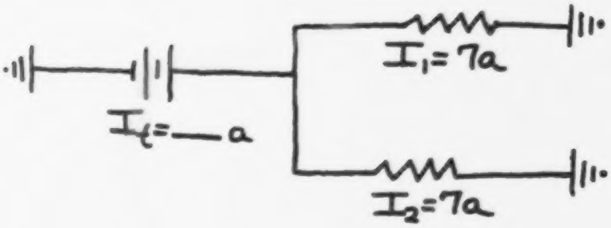
5.

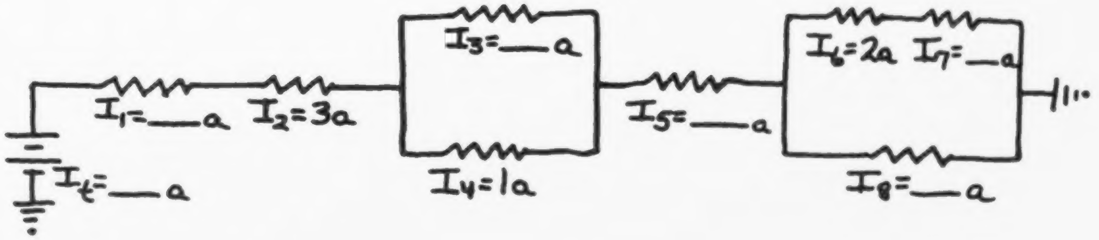

I₁ = 9a
I₂ = __ a
Iₜ = __ a
I₃ = __ a
I₄ = __ a
I₆ = 1a
I₅ = 1a

6.

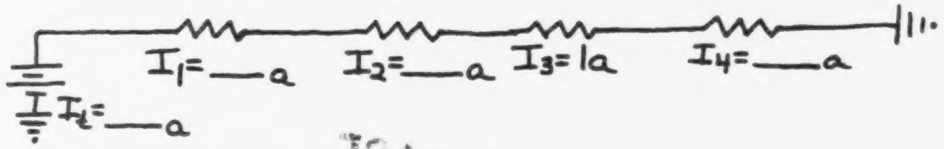

I₁ = __ a
I₂ = 4a
I₂ = 4a
I₃ = __ a

7.

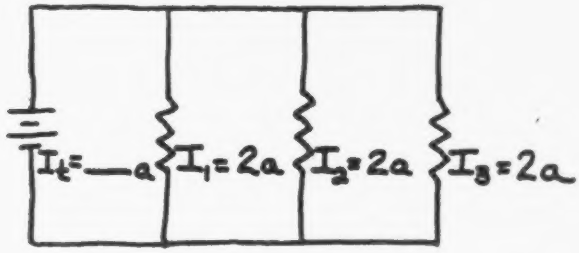

I₁ = 7a
Iₜ = __ a
I₂ = 7a


I₁=___a
I₂=3a
I₃=___a
I₄=1a
I₅=___a
I₆=2a
I₇=___a
I₈=___a
Iₜ=___a

9.


I₁=___a
I₂=___a
I₃=1a
I₄=___a
Iₜ=___a

10.


Iₜ=___a
I₁=2a
I₂=2a
I₃=2a

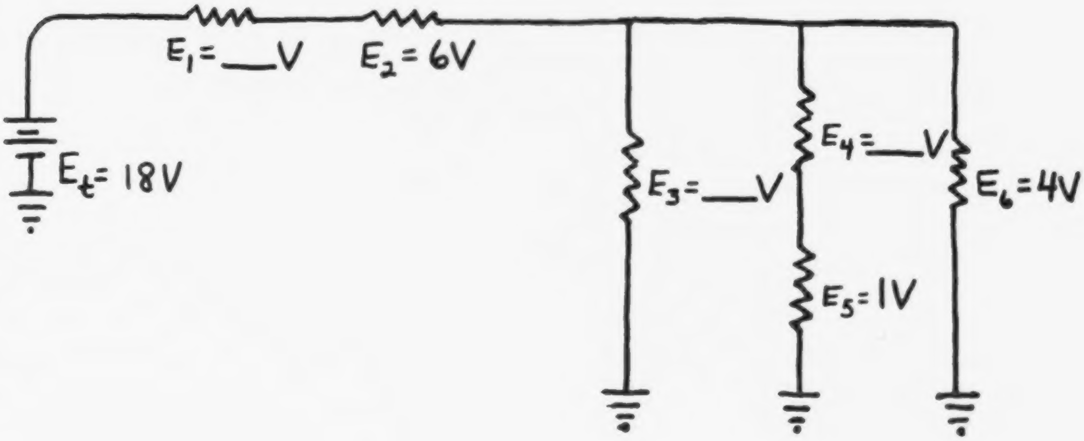
Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-HO-1133
23 May 1984

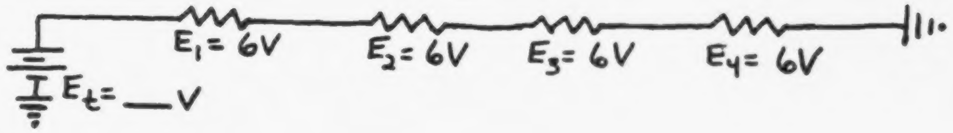
KIRCHHOFF'S VOLTAGE LAW

INSTRUCTIONS: Using Kirchhoff's Voltage Law, solve for the unknown value(s).

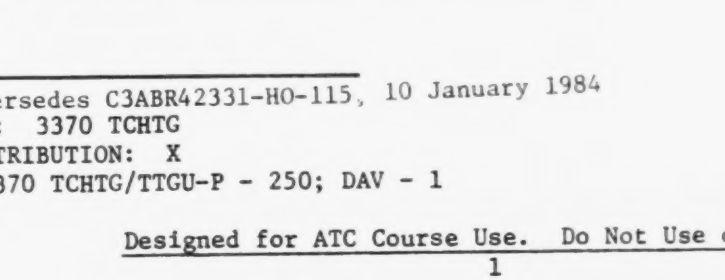
1.


E_1 = __V
E_2 = 6V
E_t = 18V
E_3 = __V
E_4 = __V
E_6 = 4V
E_5 = 1V

2.


E_1 = 6V
E_2 = 6V
E_3 = 6V
E_4 = 6V
E_t = __V

3.


E_t = __V
E_1 = 16V
E_2 = 16V
E_3 = 16V
E_4 = 16V

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OPR: 3370 TCHTG
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3370 TCHTG/TTGU-P - 250; DAV - 1

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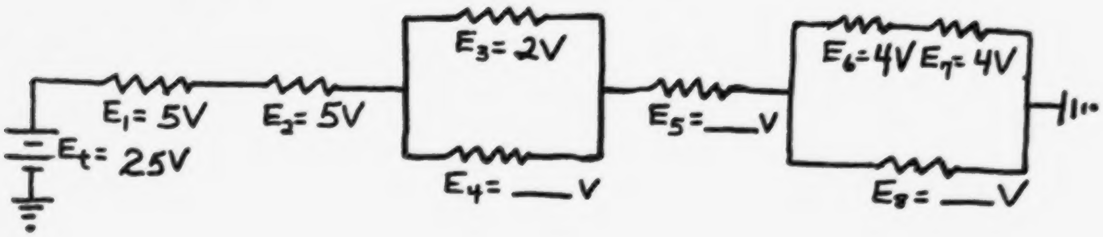
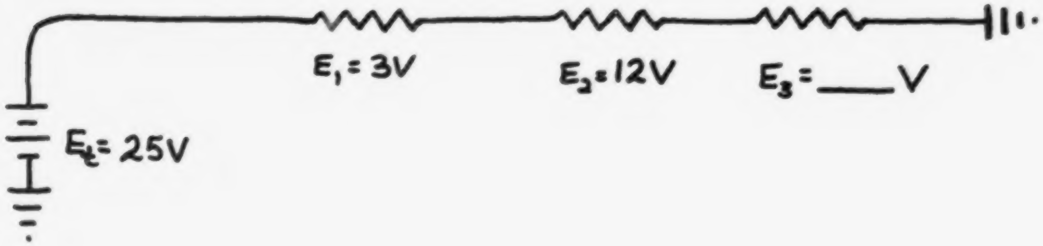
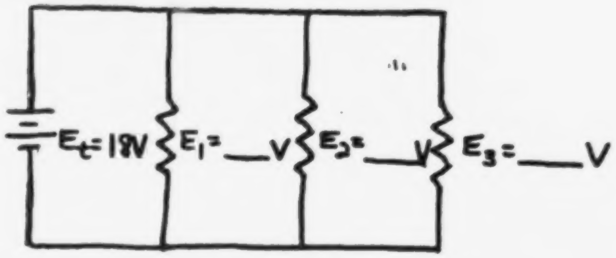
4.


E₁= 5V
E₂= 5V
E₃= 2V
E₄= ___V
E₅=___V
E₆=4V
E₇= 4V
E₈= ___V
Eₜ= 25V

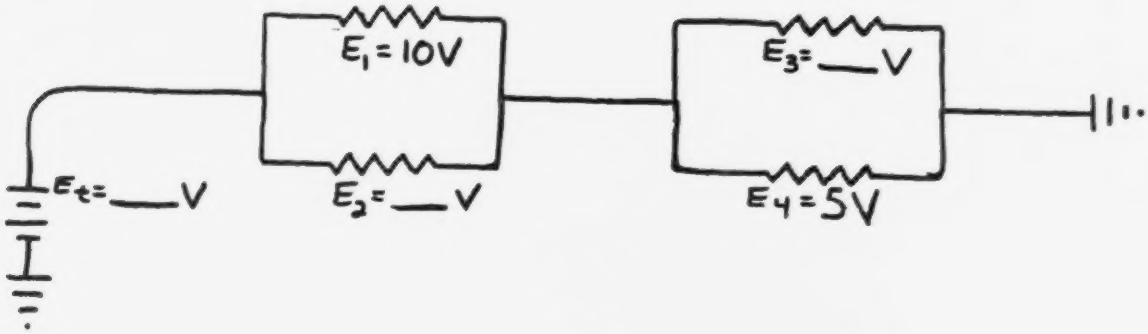
5.


E₁= 3V
E₂=12V
E₃=____V
Eₜ= 25V

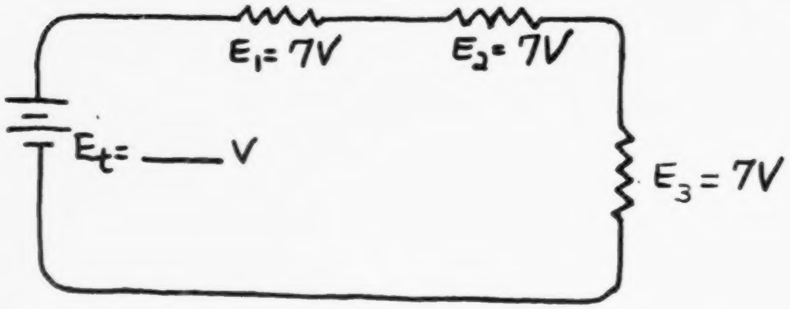
6.


Eₜ=18V
E₁=___V
E₂=___V
E₃=____V

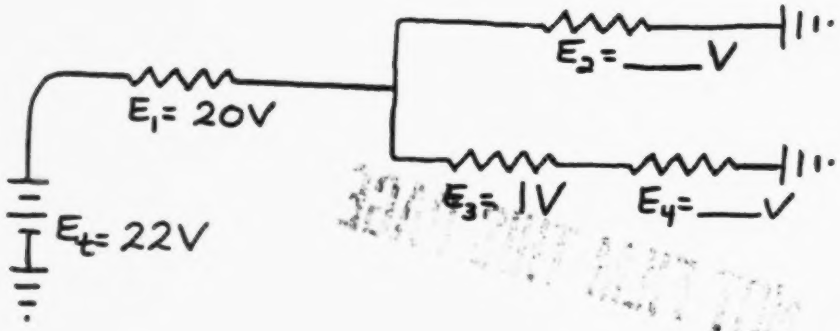
7.


E₁= 10V
E₂=___V
E₃=___V
E₄=5V
Eₜ=___V

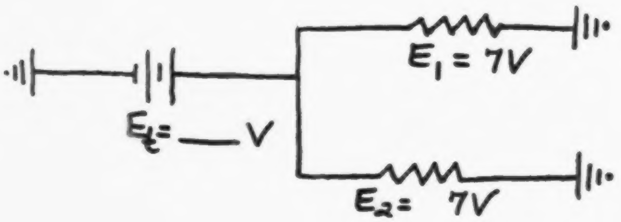
8.


E_1= 7V
E_2= 7V
E_t= ___V
E_3 = 7V

9.


E_2= ___V
E_1= 20V
E_3= 1V
E_4= ___V
E_t= 22V

10.


E_1 = 7V
E_t= ___V
E_2= 7V

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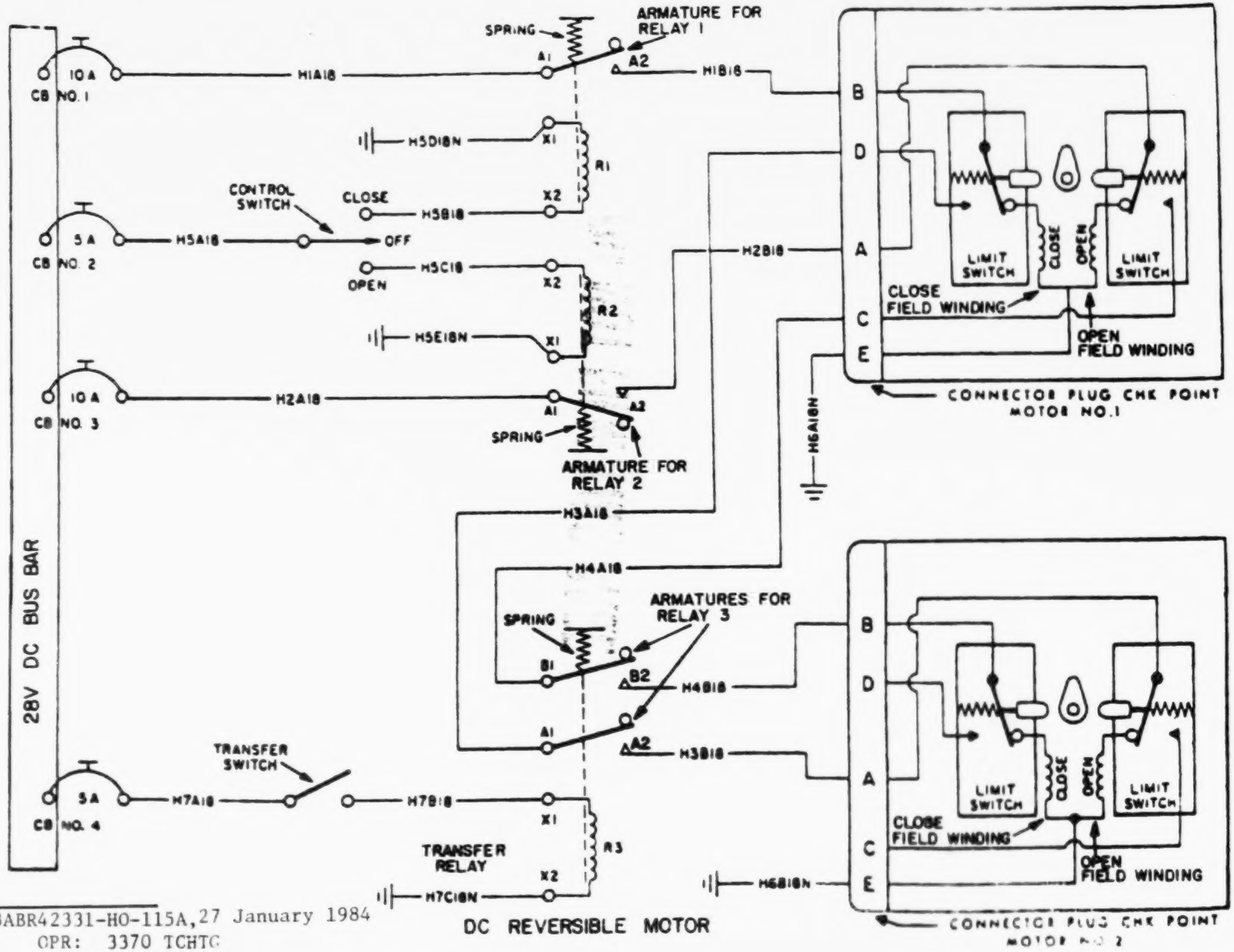
C3ABR42331-HO-115A
23 May 1984

DC MOTOR CONTROL CIRCUIT WIRING DIAGRAM


28V DC BUS BAR
CB NO. 1
10 A
H1A18
SPRING
ARMATURE FOR RELAY 1
A1
A2
H1B18
H5D18N
X1
R1
X2
CLOSE
H5B18
CONTROL SWITCH
CB NO. 2
5 A
H5A18
OFF
OPEN
H5C18
X2
R2
H5E18N
X1
CB NO. 3
10 A
H2A18
A1
A2
SPRING
ARMATURE FOR RELAY 2
H2B18
H3A18
H4A18
SPRING
ARMATURES FOR RELAY 3
B1
B2
H4B18
A1
A2
H3B18
CB NO. 4
5 A
H7A18
TRANSFER SWITCH
H7B18
X1
R3
TRANSFER RELAY
X2
H7C18N
H6A18N
H6B18N
B
D
A
C
E
LIMIT SWITCH
CLOSE
OPEN
LIMIT SWITCH
CLOSE FIELD WINDING
OPEN FIELD WINDING
CONNECTOR PLUG CHK POINT MOTOR NO. 1
CONNECTOR PLUG CHK POINT MOTOR NO. 2
DC REVERSIBLE MOTOR

Supersedes C3ABR42331-HO-115A, 27 January 1984
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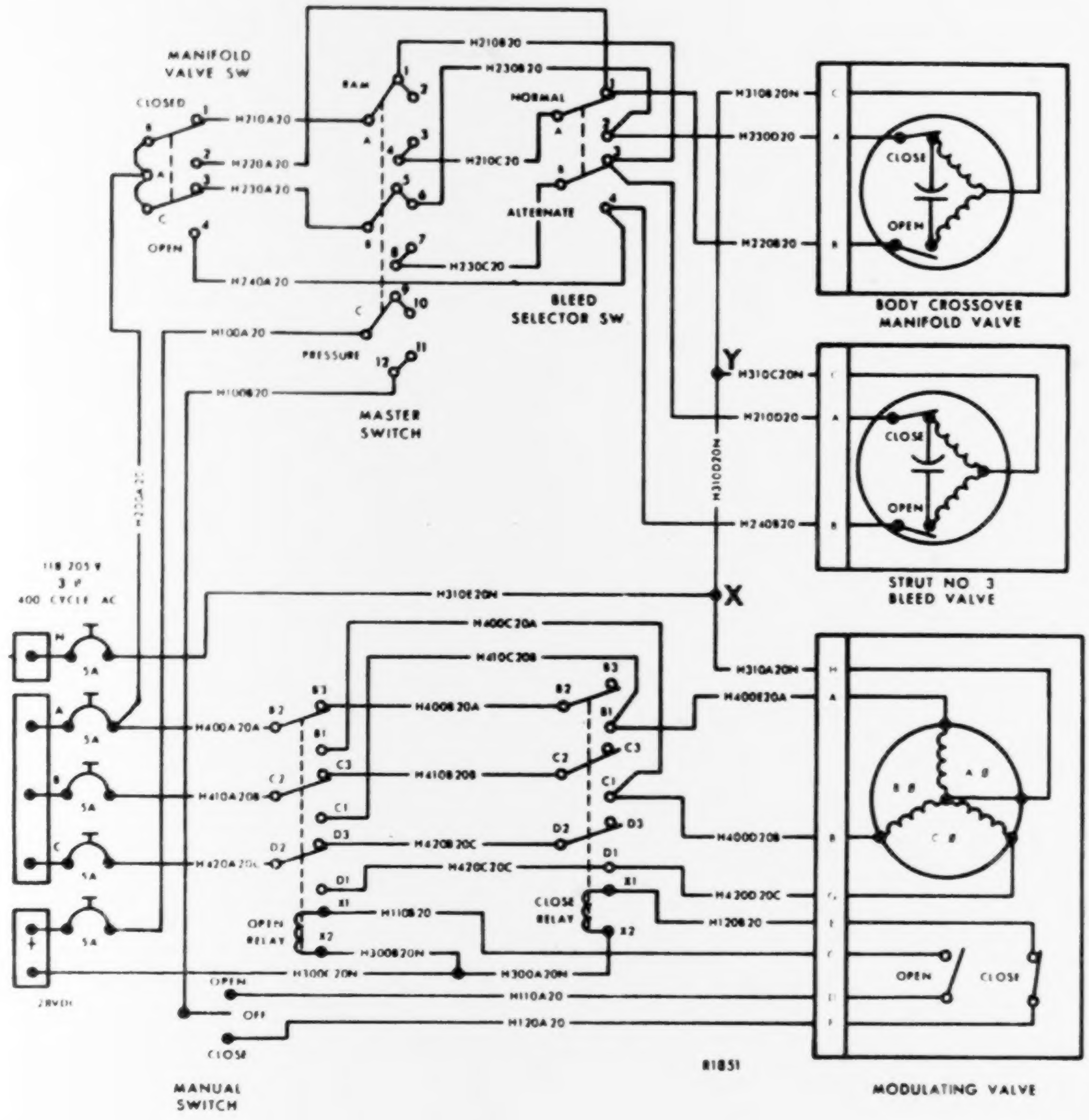
Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-HO-115B
22 August 1984

AC MOTOR WIRING DIAGRAM



MANIFOLD VALVE SW
CLOSED
OPEN
H210A20
H220A20
H230A20
H240A20
RAM
NORMAL
ALTERNATE
H210B20
H230B20
H210C20
H230C20
BLEED SELECTOR SW
H100A20
H100B20
PRESSURE
MASTER SWITCH
H310B20N
H230D20
H220B20
CLOSE
OPEN
BODY CROSSOVER MANIFOLD VALVE
Y
H310C20N
H210D20
H240B20
H310D20N
STRUT NO 3 BLEED VALVE
115 205 V
3 Ø
400 CYCLE AC
5A
28VDC
H310E20N
X
H400C20A
H410C20B
H400A20A
H410A20B
H420A20C
H400B20A
H410B20B
H420B20C
H420C20C
B1
B2
B3
C1
C2
C3
D1
D2
D3
X1
X2
OPEN RELAY
CLOSE RELAY
H110B20
H300B20N
H300C20N
H300A20N
H120B20
H310A20N
H400E20A
H400D20B
H420D20C
H110A20
H120A20
OFF
MANUAL SWITCH
A Ø
B Ø
C Ø
MODULATING VALVE
R1851

Supersedes C3ABR42331-HO-126A, 8 December 1983

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PROGRAMMED TEXT
C3ABR42331-PT-114

Technical Training

Aircraft Environmental Systems Mechanic

KIRCHHOFF'S CURRENT LAW

20 October 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 9.6

OBJECTIVE

Use Kirchhoff's current law to solve for unknown values in basic electrical circuits. A minimum of eight out of the ten unknown values must be correct.

INSTRUCTIONS

This PT presents information in small steps called "frames." Carefully study the written material and/or diagram in each frame until you are satisfied that you understand its contents. Each frame requires you to respond to the information in some way. For example, you may be required to solve for unknowns in circuits. Specific instructions are provided in each frame. After you have made your response in this book, compare your answers with the answers given on the top of the next page. If you are correct, go on to the next frame. If you are incorrect, study the frame again and correct your mistakes before continuing. Read carefully, select the correct answers and DO NOT HURRY!!

Supersedes 3ABR42331-PT-114, 9 January 1981.
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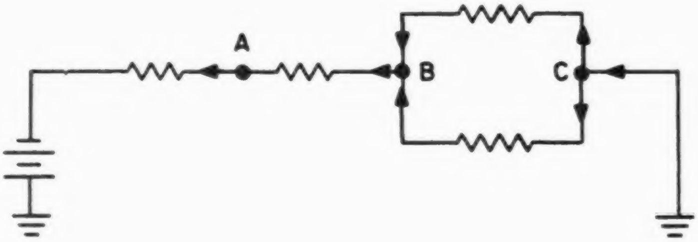
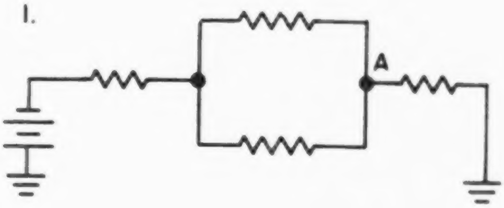
Kirchhoff's current law is stated as follows: The sum of the currents that flow into any junction of conductors is equal to the sum of the currents that flow away from that junction. In order to apply this law, you must understand what we mean by a junction of conductors. A junction is the point where two or more conductors are joined together. In the figure shown, we have identified junctions at points A, B, and C.

There is one path for current to flow into junction C and two paths for current to flow out of junction C. The arrows are indicating the direction of current flow in the circuit. There are two paths for current to flow into B and one path for current to flow out of B. There is one path for current to flow into junction A and one path for current to leave A.

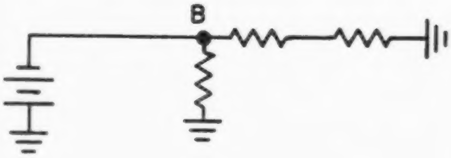


For each of the junctions lettered in the circuits below, indicate how many paths are leading into the junction and how many are leaving. Remember, current flows from a negative potential to a positive potential. The short line of the battery symbol represents the negative terminal. Put your answer on the appropriate blank on the response sheet.

1.



2.



a. How many paths leading into A? _____

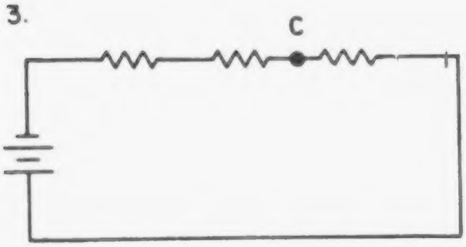
b. How many paths leaving A? _____

a. How many paths leading into B? _____

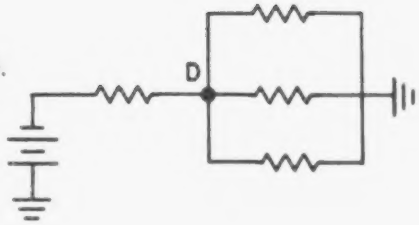
b. How many paths leaving B? _____

Frame 1 (Continued)

3.



4.



a. How many paths leading into C? _____

b. How many paths leaving C? _____

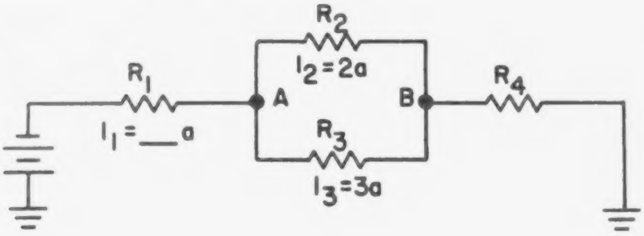
a. How many paths leading into D? _____

b. How many paths leaving D? _____

Answers to Frame 1: 1a. 1 2a. 2 3a. 1 4a. 3
b. 2 b. 1 b. 1 b. 1

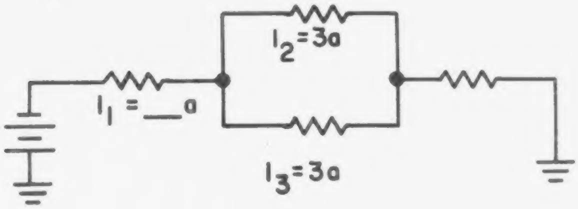
Frame 2

Now that you understand how to determine how many paths are leading into a junction and how many are leaving, you are ready to learn how to apply Kirchhoff's current law in solving for unknown currents in a circuit. First, we'll restate the law: The sum of the currents flowing into a junction of conductors is equal to the sum of the currents flowing away from that junction. To demonstrate how to apply this law we will use the circuit shown below. In the circuit below we need to find the amount of current flowing through R1. Applying Kirchhoff's current law to junction A, we have the sum of the currents flowing into A, $I_2 + I_3 =$ 5a. Thus, we must have 5a leaving A. Therefore, $I_1 = 5a$.

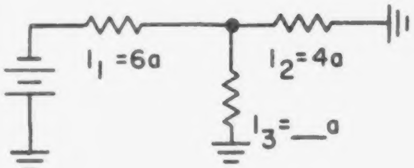


Determine the unknown current in each of the circuits below. Put your answers on the appropriate blank.

1.



2.

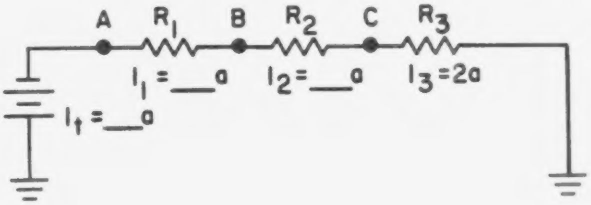


Answers to Frame 2: 1. 6a 2. 2a

Frame 3

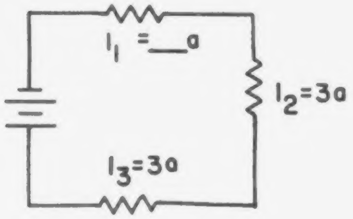
In this frame you will see that Kirchhoff's current law is valid in an actual circuit.

Since there is only one path for current flow, it must be the same at any point in the circuit. Let's see why. In the circuit below we want to find the values of I_t, I_1, and I_2. There are 2 amps flowing into junction C. Using Kirchhoff's current law we have 2 amps leaving junction C. Since there is only one path leaving junction C, the current through R_2, I_2, must also be 2 amps. Thus, we have 2 amps flowing into junction B. Since there is only one path leaving B, I_1 = 2a. Since there are 2 amps flowing into junction A and there is only one path leaving junction A, I_t must also be 2 amps. Fill in 2a for I_t, I_1, and I_2 in the circuit below.

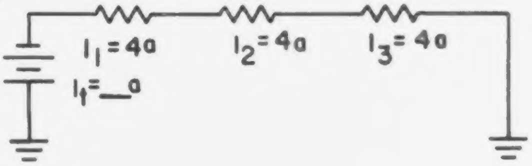


Using Kirchhoff's current law, solve for the unknown currents in each of the following circuits. Put your answers on the appropriate blank.

1.



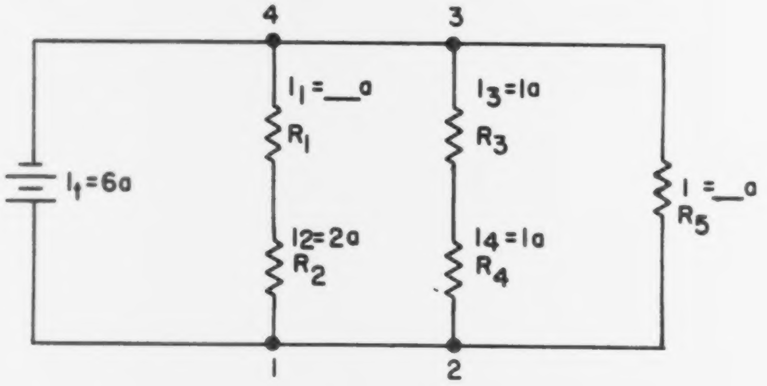
2.



Answers to Frame 3: 1. 3a 2. 4a

Frame 4

In the last frames you saw that Kirchhoff's current law is valid in an actual circuit. The remainder of this lesson is going to give you practice applying Kirchhoff's current law to various circuits. First, we'll give one more example problem that is worked out step-by-step. Since I_t = 6a in the circuit below, there are 6 amps flowing into junction 1. Applying Kirchhoff's current law we have 6 amps leaving junction 1. Since there are 2 amps flowing up through R_2, there must be 4 amps flowing into junction 2. Thus, there must be 4 amps leaving junction 2. Since there is 1 amp flowing up through R_4, there must be 3 amps flowing into R_5. Thus, I_5 = 3a. Fill in 3a for I_5. Next we want to find the value of I_1. Since there are 2 amps leaving R_2, there must be 2 amps flowing into R_1. Thus, I_1 = 2a. Fill in 2a for I_1.

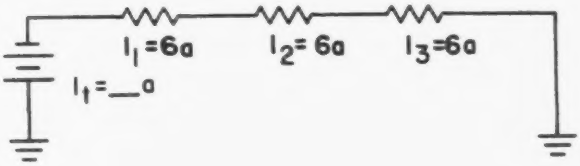


NO FURTHER RESPONSE REQUIRED, PROCEED TO THE NEXT FRAME.

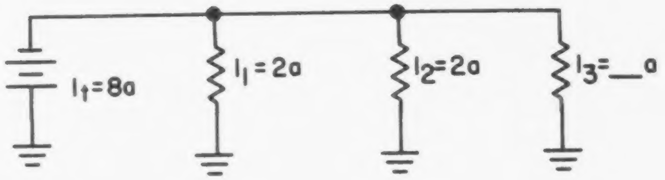
Frame 5

Using Kirchhoff's current law, analyze the circuits below to determine the unknown current in each circuit. Put your answers on the appropriate blank.

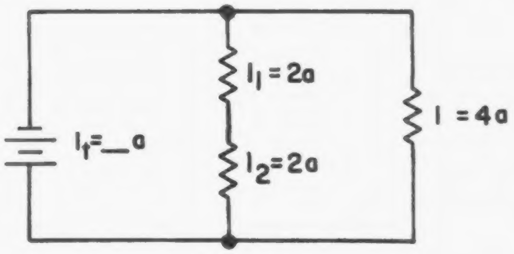
1.


I_1=6a
I_2= 6a
I_3=6a
I_t=__a

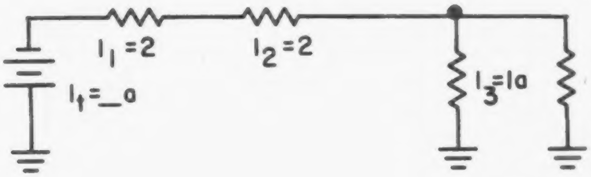
2.


I_t=8a
I_1 = 2a
I_2=2a
I_3=__a

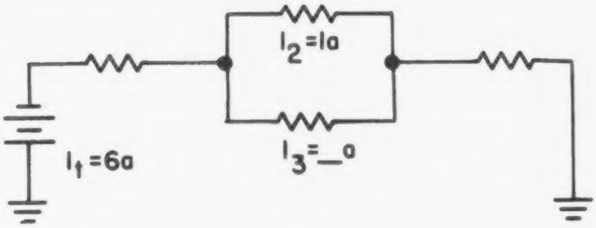
3.


I_t=__a
I_1 = 2a
I_2=2a
I =4a

4.


I_1 =2
I_2 =2
I_t=_a
I_3=1a

5.

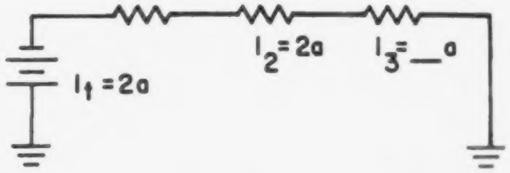

I_2=1a
I_3=_a
I_t =6a

Answers to Frame 5: 1. 6a 2. 4a 3. 6a 4. 2a 5. 5a

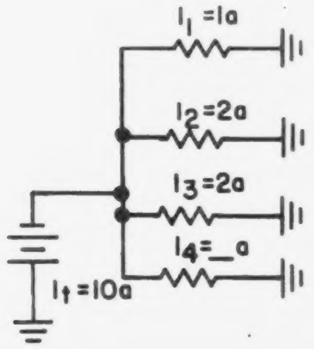
Frame 6

Using Kirchhoff's current law, analyze the circuits below to determine the unknown current in each circuit. Put your answers on the appropriate blank.

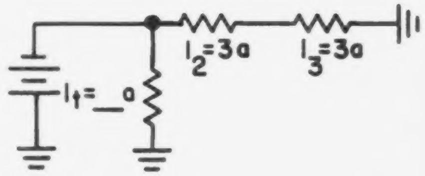
1.


$I_t = 2a$
$I_2 = 2a$
$I_3 = \_\_a$

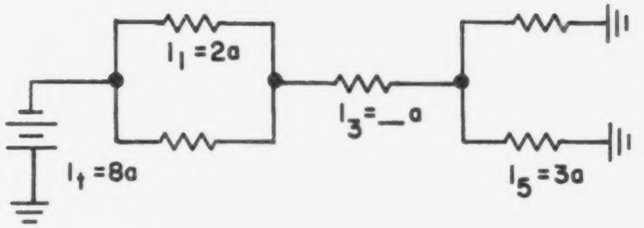
2.


$I_1 = 1a$
$I_2 = 2a$
$I_3 = 2a$
$I_4 = \_\_a$
$I_t = 10a$

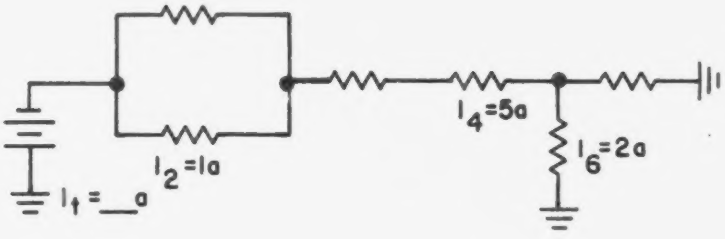
3.


$I_t = \_\_a$
$I_2 = 3a$
$I_3 = 3a$

4.


$I_1 = 2a$
$I_t = 8a$
$I_3 = \_\_a$
$I_5 = 3a$

5.

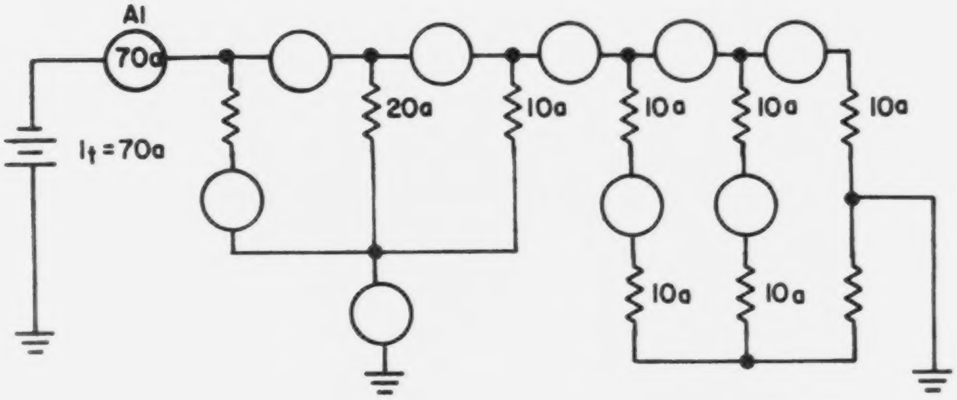

$I_t = \_\_a$
$I_2 = 1a$
$I_4 = 5a$
$I_6 = 2a$

Answers to Frame 6: 1. 2a 2. 5a 3. 5a 4. 8a 5. 5a

Frame 7

Using Kirchhoff's current law analyze the circuits below to determine the unknown current in each circuit. Put your answers on the appropriate blank. After you complete the following problems see your instructor for grading.

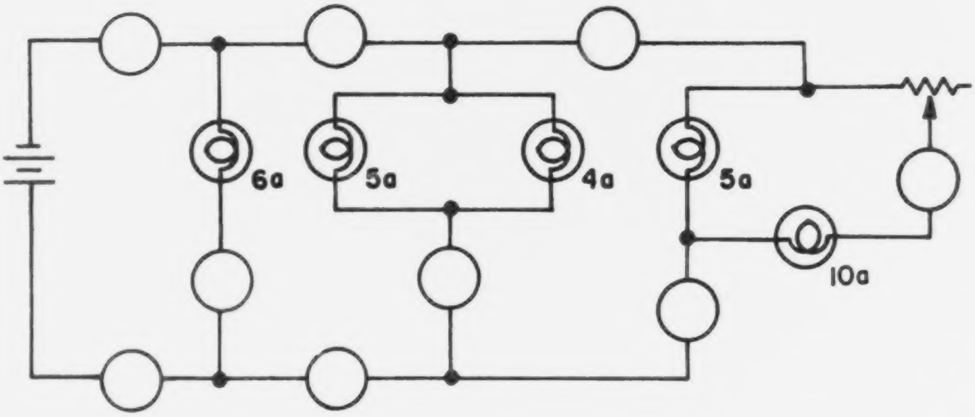
1.



A1
70a
I_t=70a
20a
10a
10a
10a
10a
10a
10a

Fill in the ammeter readings in the circuit below.

2.



6a
5a
4a
5a
10a

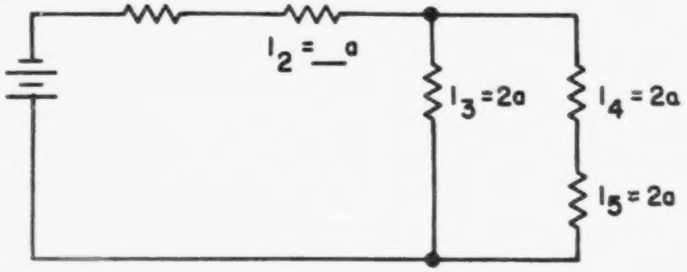
Have the instructor check your answers.

Instructor's Initials ________

Frame 8

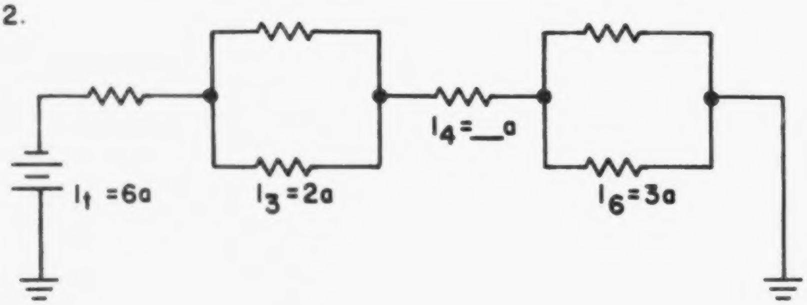
Using Kirchhoff's current law Analyze the circuits below to determine the unknown current in each circuit. Put your answers on the appropriate blank. After you complete the following ten (10) problems see your instructor for grading.

1.



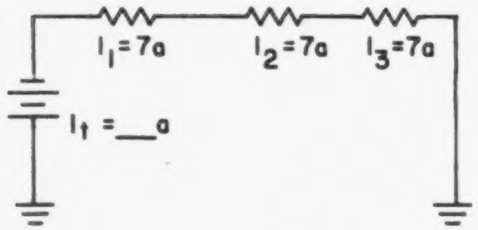
I2 = __a
I3 = 2a
I4 = 2a
I5 = 2a

2.



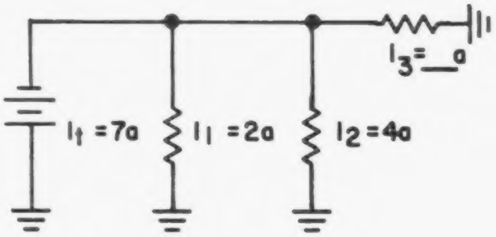
It = 6a
I3 = 2a
I4 = __a
I6 = 3a

3.



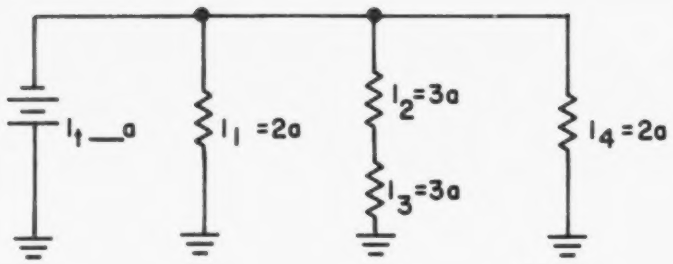
I1 = 7a
I2 = 7a
I3 = 7a
It = __a

4.



It = 7a
I1 = 2a
I2 = 4a
I3 = __a

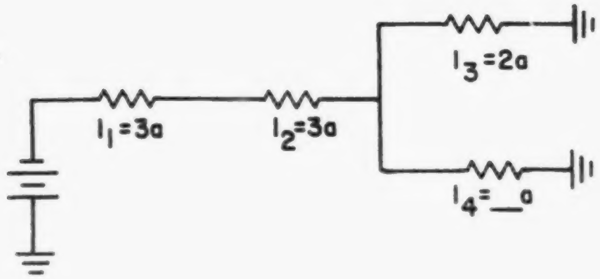
5.



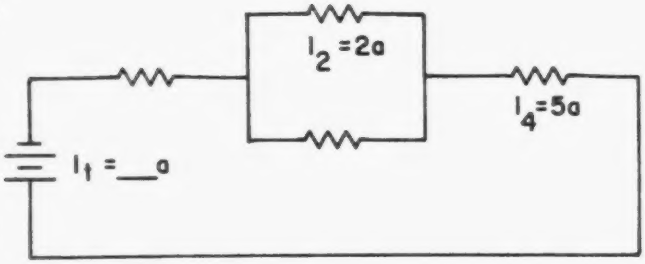
It __a
I1 = 2a
I2 = 3a
I3 = 3a
I4 = 2a

Frame 8 (Cont'd)

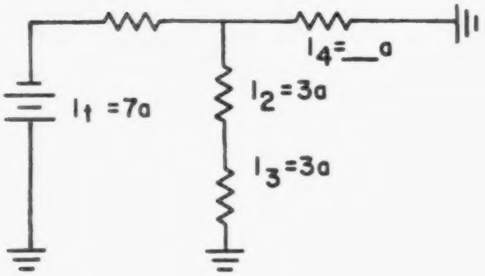
6.


$I_1=3a$
$I_2=3a$
$I_3=2a$
$I_4=\_\_a$

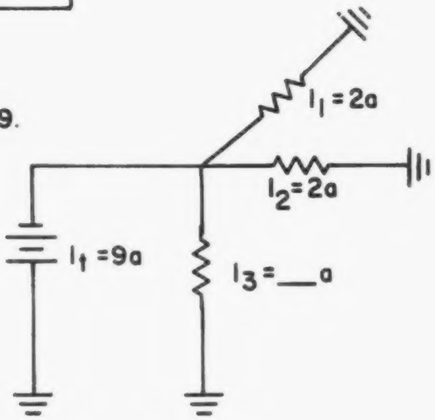
7.


$I_2=2a$
$I_4=5a$
$I_t=\_\_a$

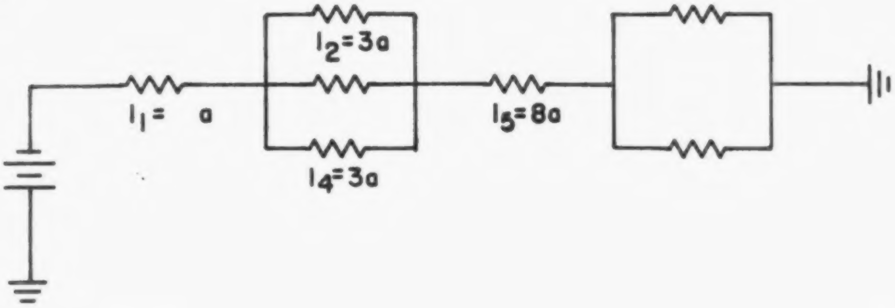
8.


$I_4=\_\_a$
$I_t=7a$
$I_2=3a$
$I_3=3a$

9.


$I_1=2a$
$I_2=2a$
$I_t=9a$
$I_3=\_\_a$

10.


$I_2=3a$
$I_1=\ \ a$
$I_5=8a$
$I_4=3a$

Have the instructor check your answers.

Instructor's Initials ________

SERVICE TEST
HANDOUT

C3ABR42331-HO-~~117B~~
114A

Technical Training

Aircraft Environmental Systems Mechanic

SERIES CIRCUIT TROUBLESHOOTING

8 December 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

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Environmental Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-HO-117B

SERIES CIRCUIT TROUBLESHOOTING

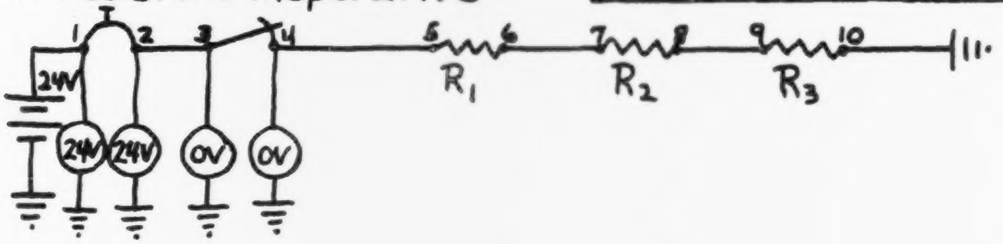
INSTRUCTIONS

Using the malfunction indications and meter readings, locate and record the probable malfunction.

Part 1a - Opens (Voltmeter)

1. All resistors inoperative

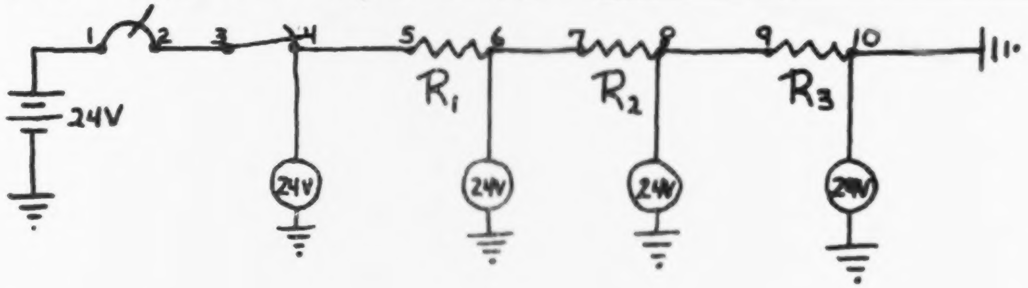
1. ______________________________



1
2
3
4
5
6
7
8
9
10
24V
R1
R2
R3
24V
24V
0V
0V

2. All resistors inoperative

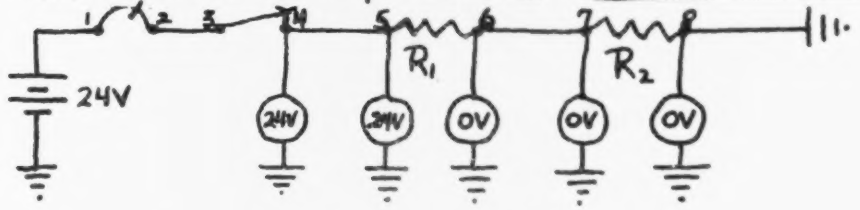
2. ______________________________



1
2
3
4
5
6
7
8
9
10
24V
R1
R2
R3
24V
24V
24V
24V

3. All resistors inoperative

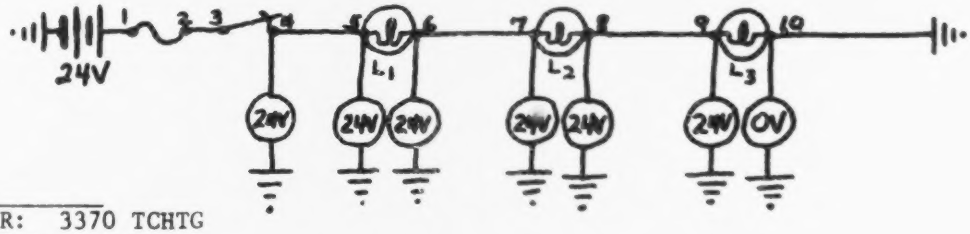
3. ______________________________



1
2
3
4
5
6
7
8
24V
R1
R2
24V
24V
0V
0V
0V

4. All lights inoperative

4. ______________________________

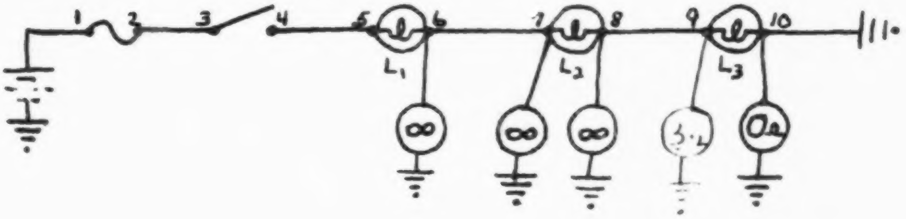


24V
1
2
3
4
5
6
7
8
9
10
L1
L2
L3
24V
24V
24V
24V
24V
24V
0V

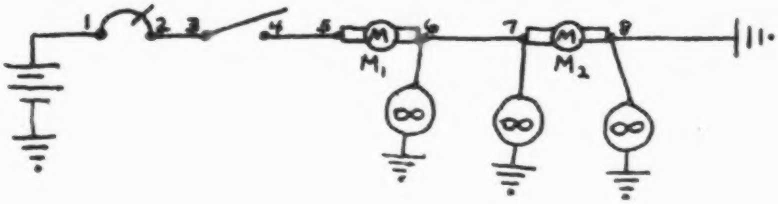
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 150; DAV - 1

Part 1b - Opens (Ohmmeter)

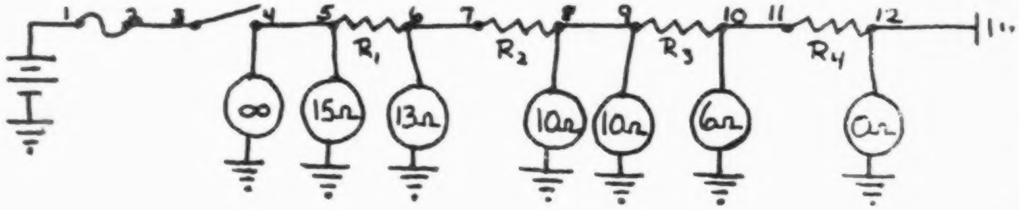
5. All lights inoperative 5. ______________________


1
2
3
4
5
6
7
8
9
10
L₁
L₂
L₃
∞
∞
∞
3Ω
0Ω

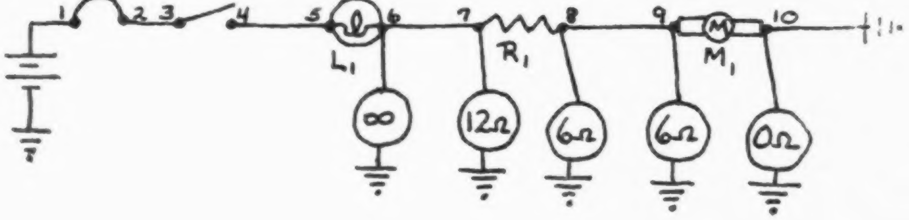
6. All motors inoperative 6. ______________________


1
2
3
4
5
6
7
8
M₁
M₂
∞
∞
∞

7. All resistors inoperative 7. ______________________


1
2
3
4
5
6
7
8
9
10
11
12
R₁
R₂
R₃
R₄
∞
15Ω
13Ω
10Ω
10Ω
6Ω
0Ω

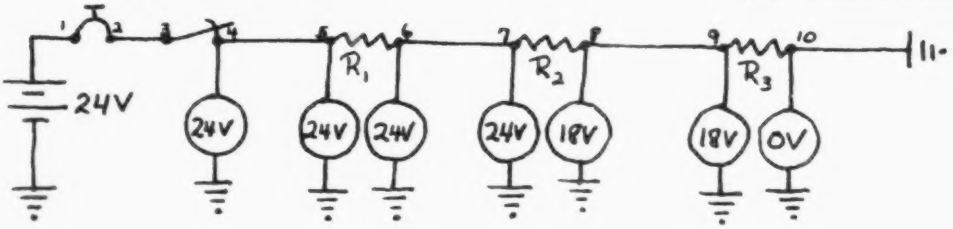
8. Everything inoperative 8. ______________________


1
2
3
4
5
6
7
8
9
10
L₁
R₁
M₁
∞
12Ω
6Ω
6Ω
0Ω

Part 2a - Shorts (Voltmeter)

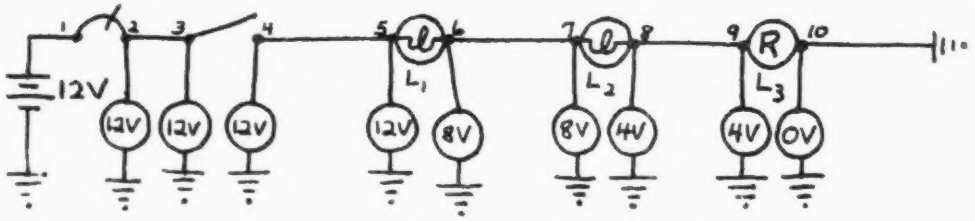
1. R_1 inoperative

1. ____________________


1
2
3
4
5
6
7
8
9
10
R_1
R_2
R_3
24V
24V
24V
24V
24V
18V
18V
0V

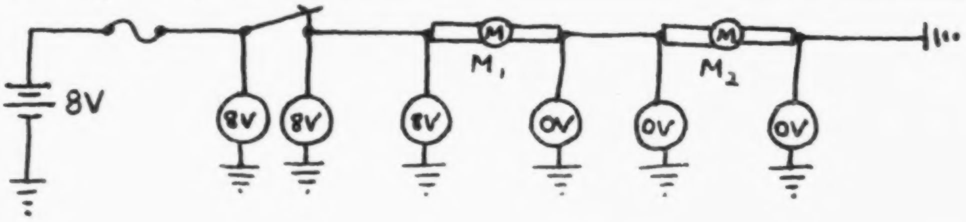
2. Lights cannot be turned off

2. ____________________


1
2
3
4
5
6
7
8
9
10
L_1
L_2
L_3
R
12V
12V
12V
12V
12V
8V
8V
4V
4V
0V

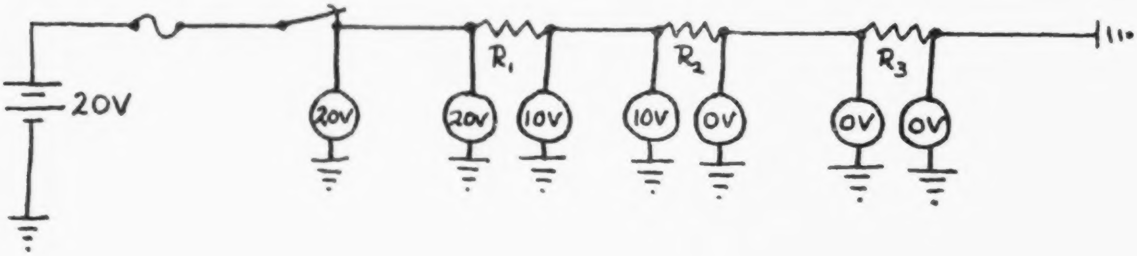
3. M_2 inoperative

3. ____________________


M
M
M_1
M_2
8V
8V
8V
8V
0V
0V
0V

4. R_3 inoperative

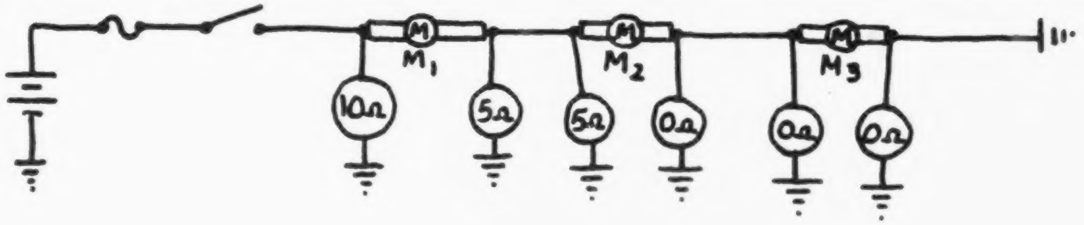
4. ____________________


R_1
R_2
R_3
20V
20V
20V
10V
10V
0V
0V
0V

Part 2b- Shorts (Ohmmeter)

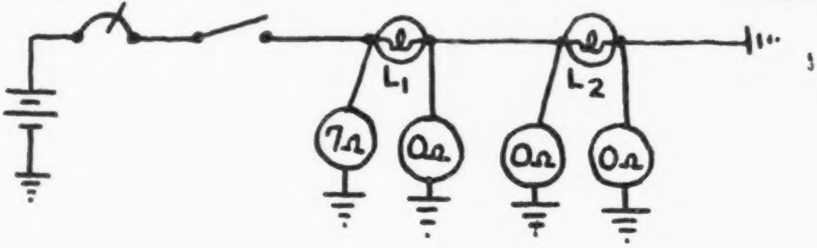
5. M₃ inoperative

5. ______________________


M
M₁
M₂
M₃
10Ω
5Ω
5Ω
0Ω
0Ω
0Ω

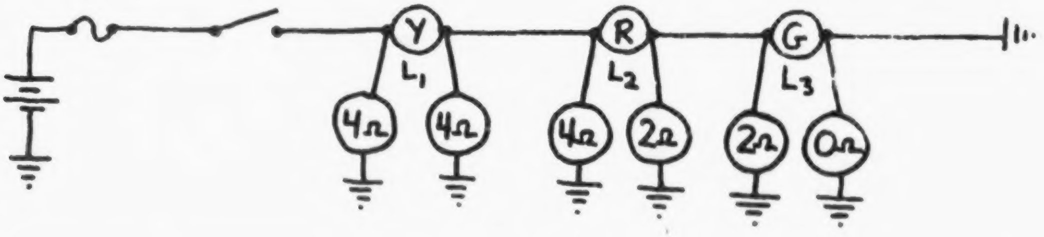
6. L₂ inoperative

6. ______________________


L₁
L₂
7Ω
0Ω
0Ω
0Ω

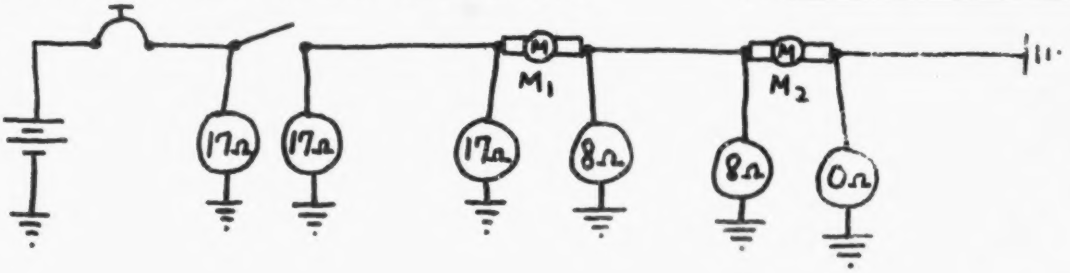
7. L₁ inoperative

7. ______________________


Y
R
G
L₁
L₂
L₃
4Ω
4Ω
4Ω
2Ω
2Ω
0Ω

8. Motors cannot be turned off

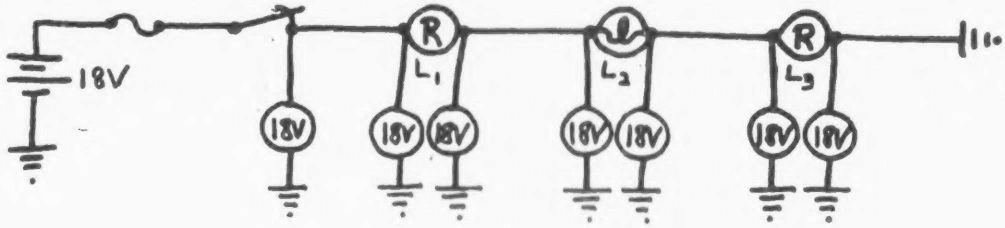
8. ______________________


M
M₁
M₂
17Ω
17Ω
17Ω
8Ω
8Ω
0Ω

Part 3a - Opens and Shorts (Voltmeter)

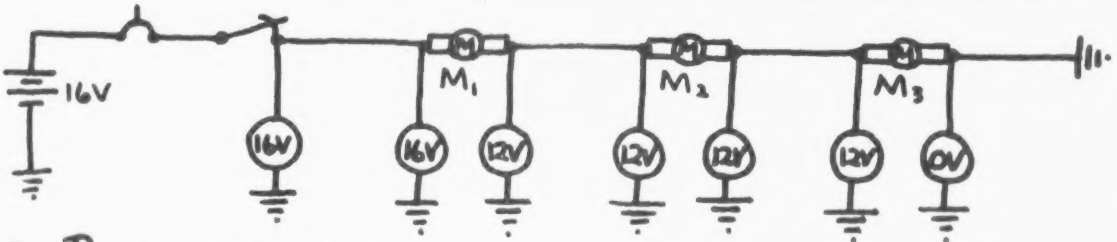
1. All lights inoperative

1. ______________________________


18V
R
L1
L2
R
L3
18V
18V
18V
18V
18V
18V
18V

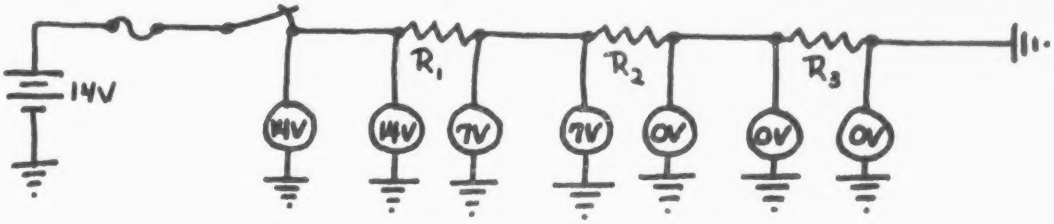
2. M2 inoperative

2. ______________________________


16V
M1
M2
M3
16V
16V
12V
12V
12V
12V
0V

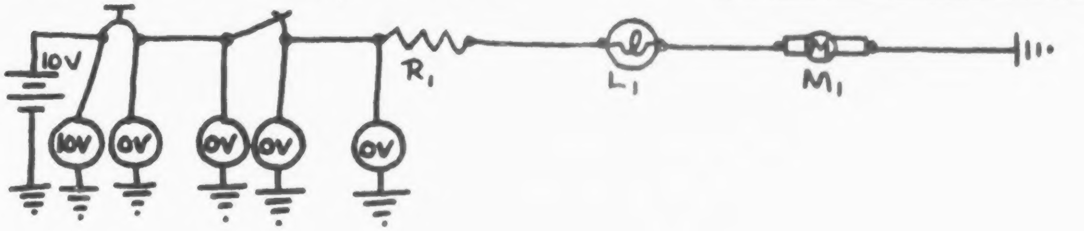
3. R3 inoperative

3. ______________________________


14V
R1
R2
R3
14V
14V
7V
7V
0V
0V
0V

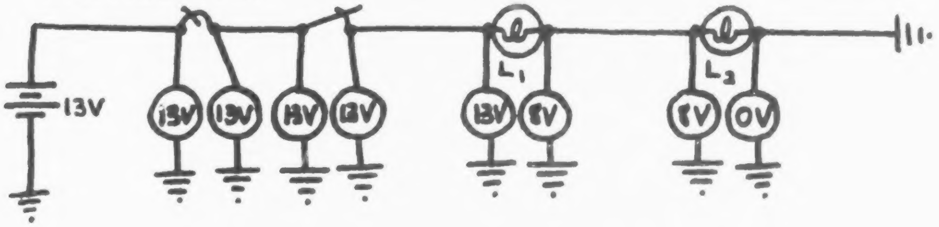
4. All loads inoperative

4. ______________________________


10V
R1
L1
M1
10V
0V
0V
0V
0V

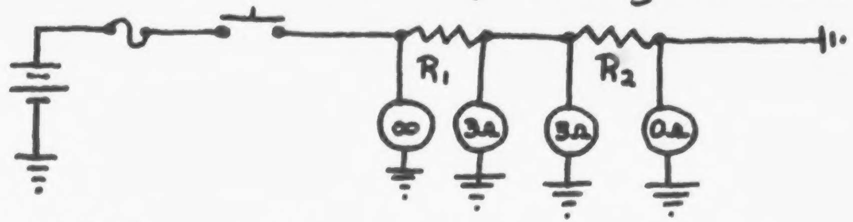
5. Lights stay on with circuit breaker turned off.

5. ______________________________


13V
L1
L2
13V
13V
13V
12V
13V
8V
8V
0V

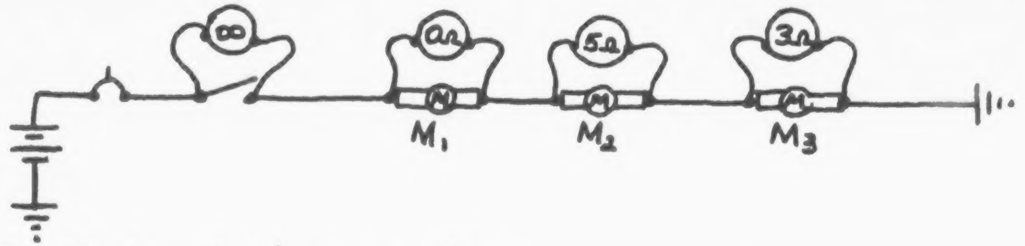
Part 3b- Opens and Shorts (Ohmmeter)

1. Resistors didnot drop voltage 1. ____________________



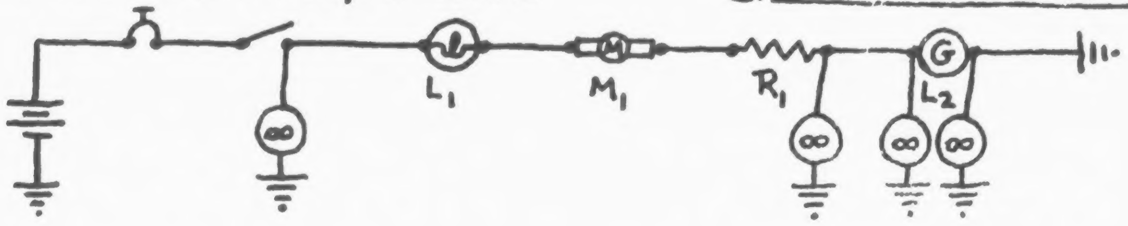
R₁
R₂
∞
3Ω
3Ω
0Ω

2. M₁ inoperative 2. ____________________

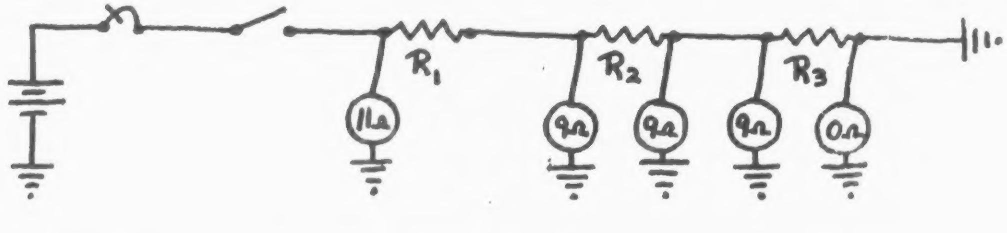


∞
0Ω
5Ω
3Ω
M
M
M
M₁
M₂
M₃

3. All loads inoperative 3. ____________________

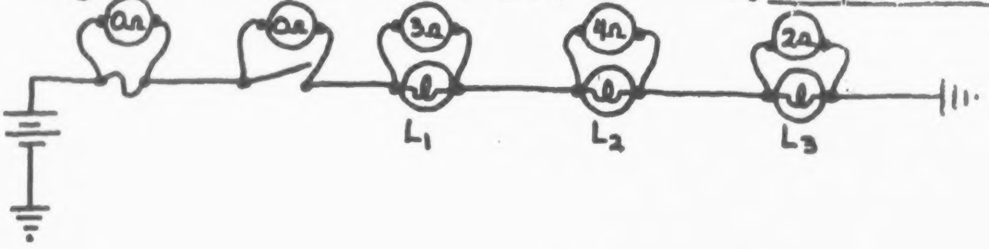


4. R₂ inoperative 4. ____________________



R₁
R₂
R₃
11Ω
9Ω
9Ω
9Ω
0Ω

5. Lights will not turn off 5. ____________________

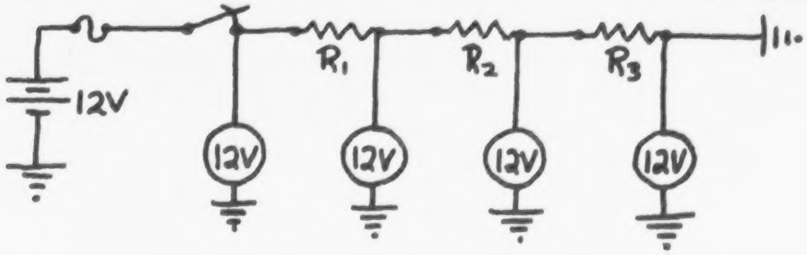


0Ω
0Ω
3Ω
4Ω
2Ω
L₁
L₂
L₃

Part 4 - Opens and Shorts (Volt and Ohmmeters)

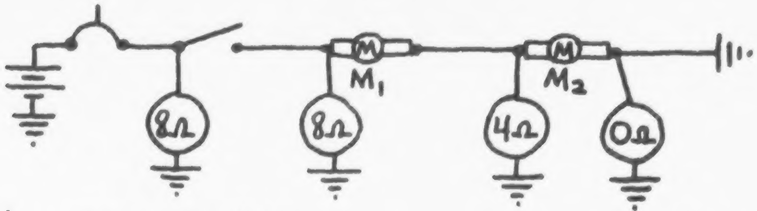
1. Resistors do not work

1. ____________________


12V
R₁
R₂
R₃
12V
12V
12V
12V

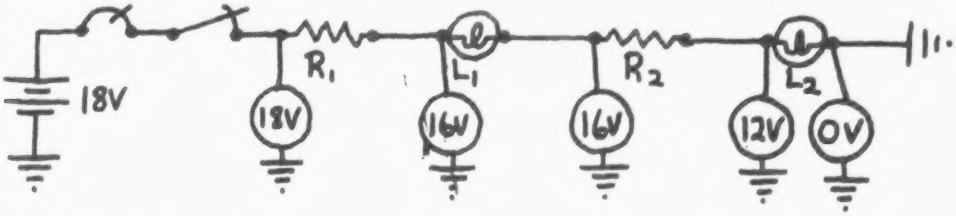
2. Motors run when turned off

2. ____________________


M₁
M₂
8Ω
8Ω
4Ω
0Ω

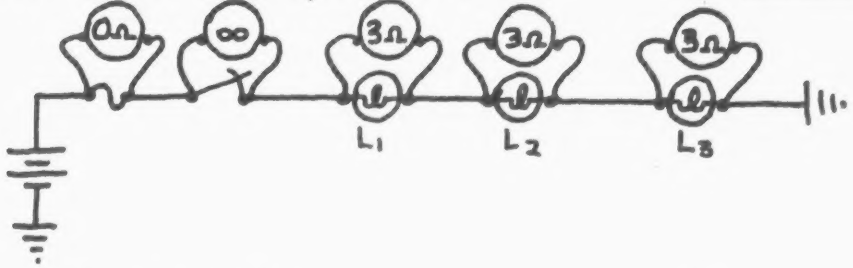
3. L₁ inoperative

3. ____________________


18V
R₁
L₁
R₂
L₂
18V
16V
16V
12V
0V

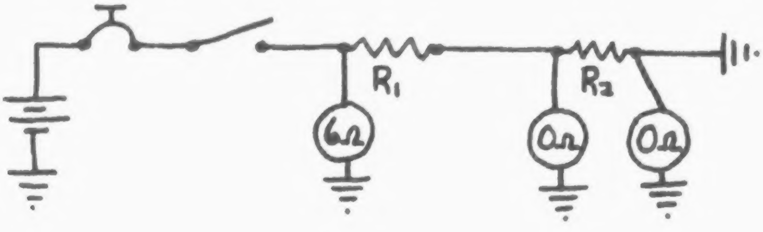
4. All lights inoperative

4. ____________________


0Ω
∞
3Ω
3Ω
3Ω
L₁
L₂
L₃

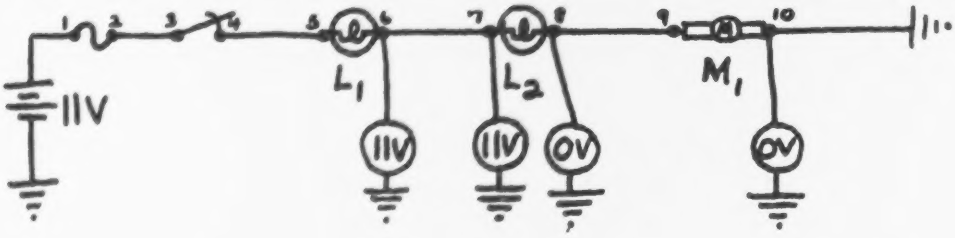
5. R₂ inoperative

5. ____________________


R₁
R₂
6Ω
0Ω
0Ω

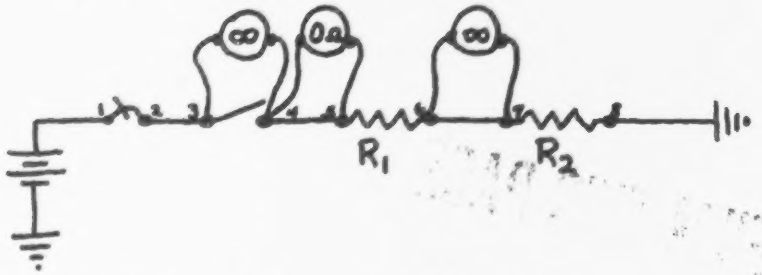
6. All loads do not work

6. ______________________


1
2
3
4
5
6
7
8
9
10
11V
L1
L2
M1
11V
11V
0V
0V

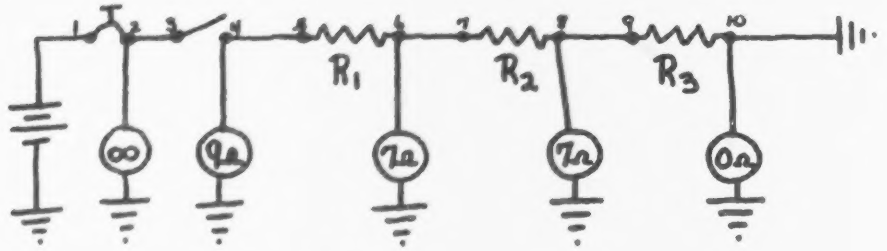
7. R1 and R2 do not work

7. ______________________


∞
0Ω
∞
1
2
3
4
5
6
7
8
R1
R2

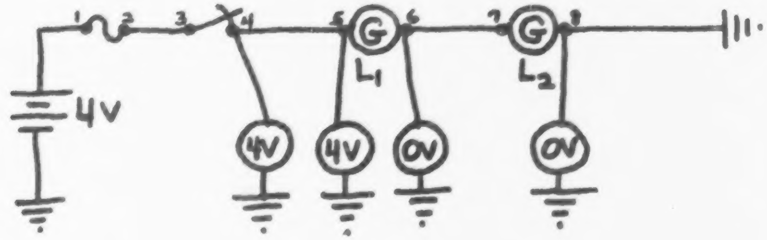
8 R2 will not drop voltage

8. ______________________


1
2
3
4
5
6
7
8
9
10
R1
R2
R3
∞
9Ω
7Ω
7Ω
0Ω

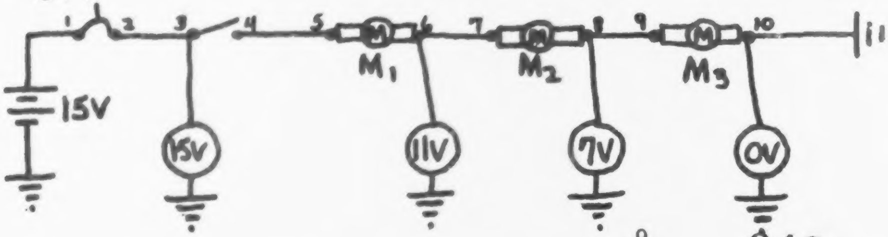
9. L2 inoperative

9. ______________________


1
2
3
4
5
6
7
8
G
G
L1
L2
4V
4V
4V
0V
0V

10. Motors will not stop when turned off

10. ______________________


1
2
3
4
5
6
7
8
9
10
M
M
M
M1
M2
M3
15V
15V
11V
7V
0V

SERVICE TEST
HANDOUT

C3ABR42331-HO-~~117B~~
114B

Technical Training

Aircraft Environmental Systems Mechanic

PARALLEL CIRCUIT TROUBLESHOOTING

9 December 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY

STANDARD COVERSHEET

Environmental Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-HO-117B

PARALLEL CIRCUIT TROUBLESHOOTING

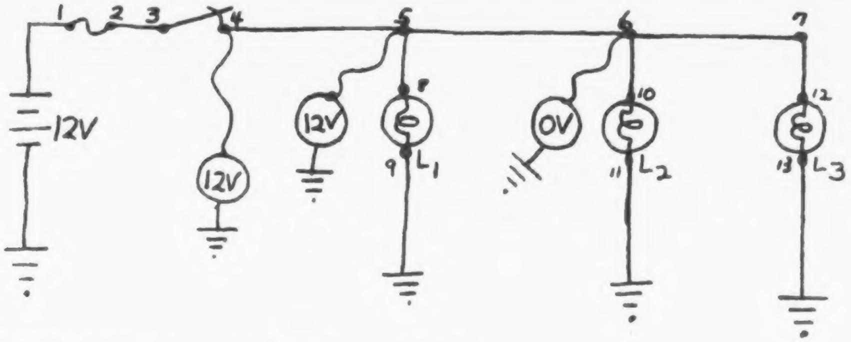
INSTRUCTIONS

Using the malfunction indication and meter readings, locate and record the probable.

Part 1a - Opens (Voltmeter)

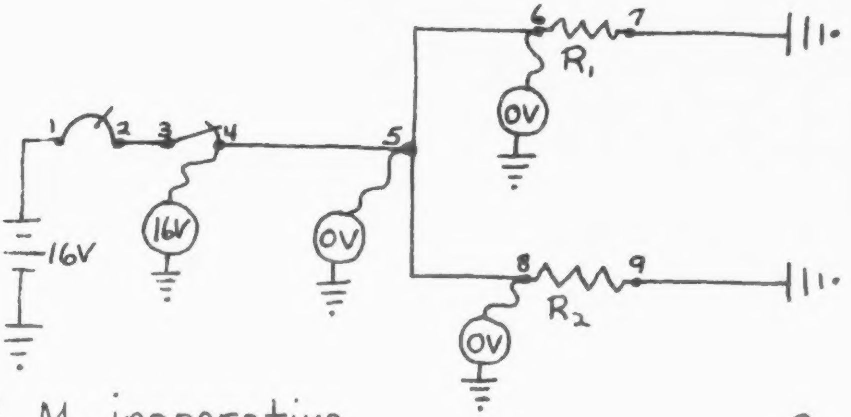
1. L₂ and L₃ inoperative

1. ____________________


1
2
3
4
5
6
7
12V
12V
12V
8
9
L₁
0V
10
11
L₂
12
13
L₃

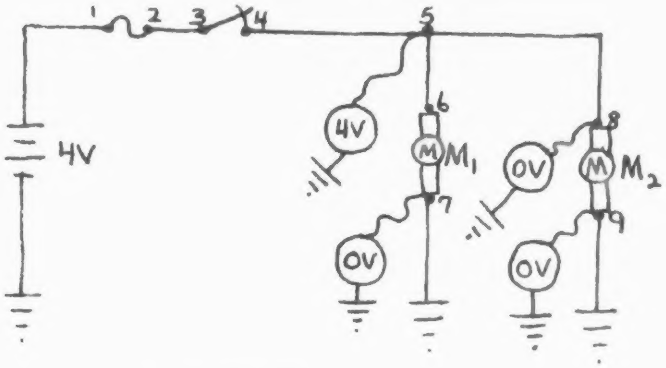
2 Neither resistor will drop voltage

2. ____________________


6
7
R₁
0V
1
2
3
4
5
16V
16V
0V
8
9
R₂
0V

3. M₂ inoperative

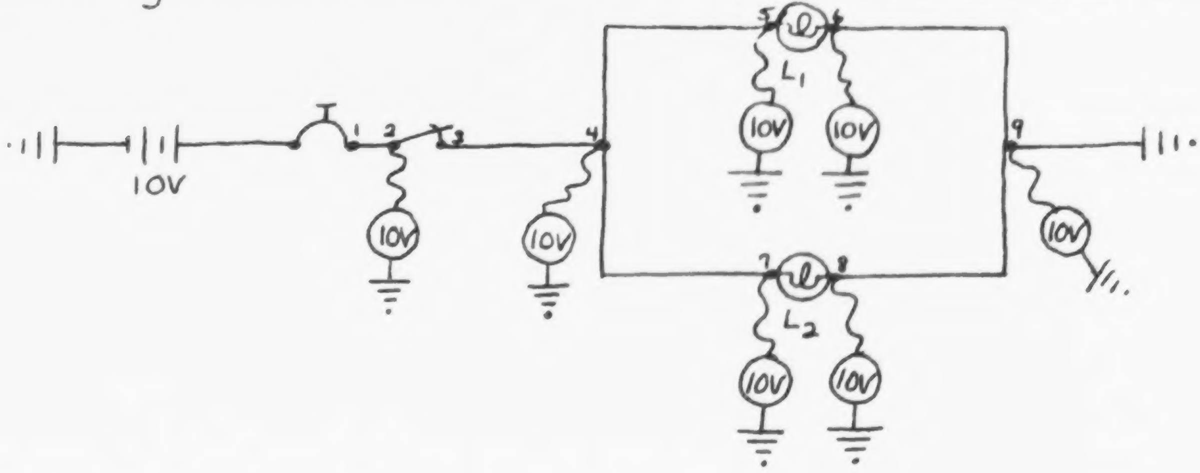
3. ____________________


1
2
3
4
5
4V
4V
6
M
M₁
7
0V
8
0V
M
M₂
9
0V

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 150; DAV - 1

4. Both lights won't work

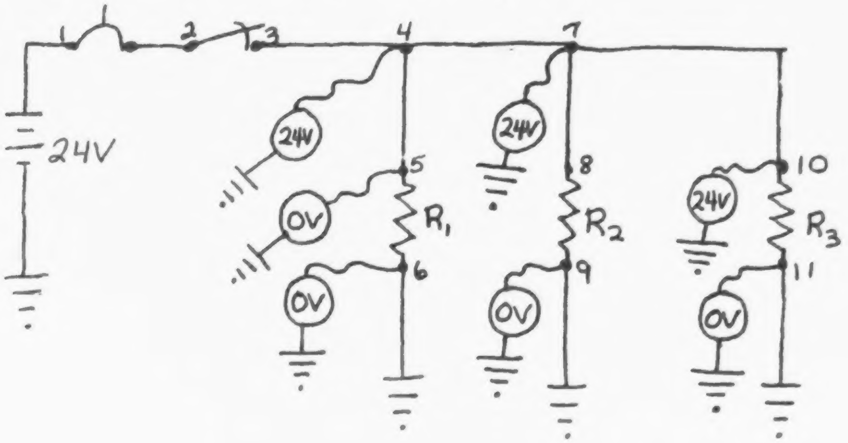
4. ______________________



10V
1
2
3
4
5
6
7
8
9
L1
L2
10V
10V
10V
10V
10V
10V
10V
10V

5. R1 will not drop voltage

5. ______________________

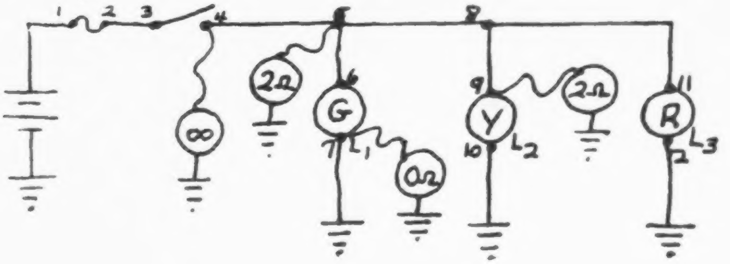


1
2
3
4
7
24V
24V
24V
24V
5
6
8
9
10
11
R1
R2
R3
0V
0V
0V
0V

Part 1b - Opens (Ohmmeter)

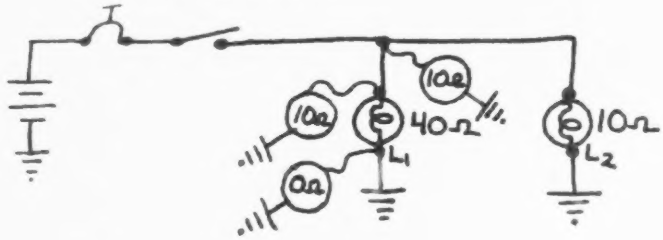
6. Lights won't work

6. ____________________


1
2
3
4
5
8
2Ω
6
G
∞
7
L1
0Ω
9
Y
10
L2
2Ω
11
R
12
L3

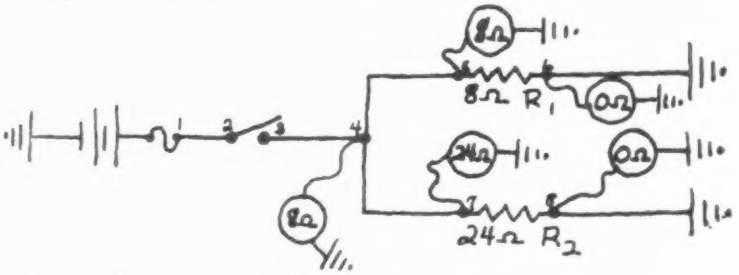
7. L1 inoperative

7. ____________________


10Ω
10Ω
40Ω
0Ω
L1
10Ω
L2

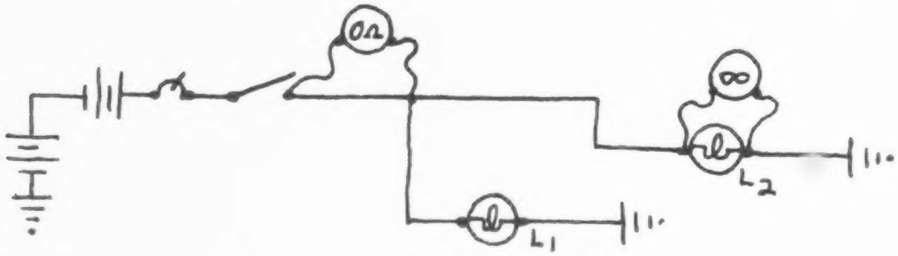
8. R2 inoperative

8. ____________________


8Ω
8Ω R1
0Ω
1
2
3
4
24Ω
0Ω
8Ω
7
8
24Ω R2

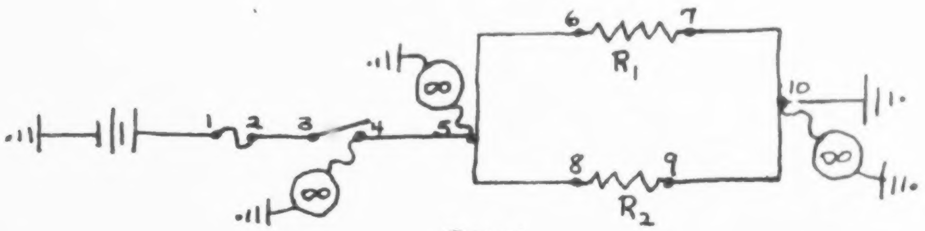
9. L2 inoperative

9. ____________________



10. Both resistors inoperative

10. ____________________

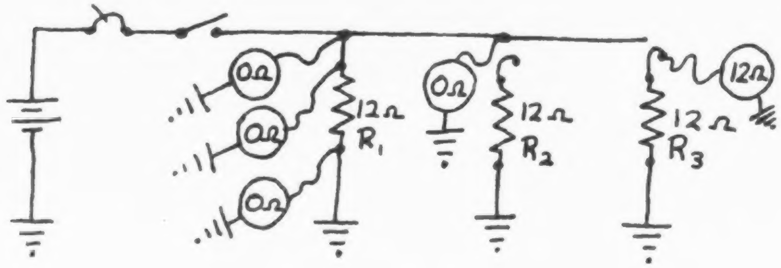

6
7
R1
∞
1
2
3
4
5
10
∞
∞
8
9
R2

Part 2 - Shorts (Ohmmeter)

(Note: You cannot troubleshoot shorts in a parallel circuit with a voltmeter.)

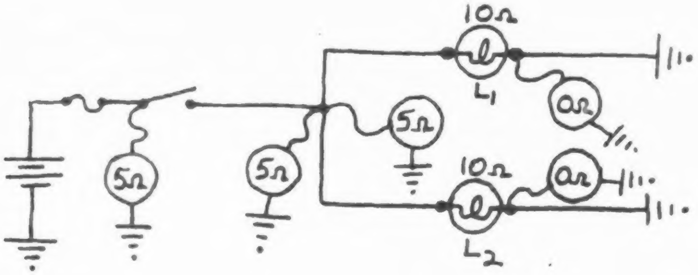
1. R₁, R₂ and R₃ will not work

1. ______________________


0Ω
0Ω
0Ω
12Ω
R₁
0Ω
12Ω
R₂
12Ω
R₃
12Ω

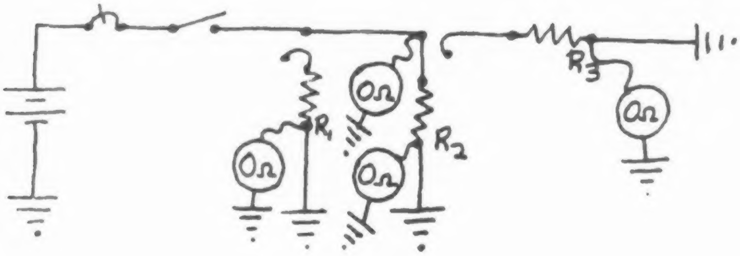
2. Lights will not turn off

2. ______________________


10Ω
L₁
0Ω
5Ω
5Ω
5Ω
10Ω
0Ω
L₂

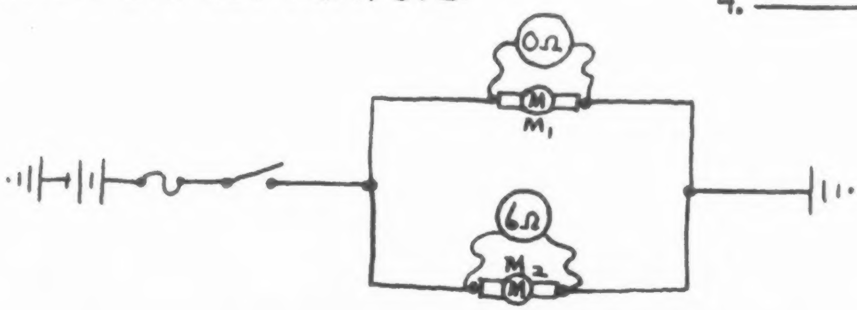
3. R₂ will not drop voltage

3. ______________________


0Ω
R₁
0Ω
0Ω
R₂
R₃
0Ω

4. Motors will not turn over

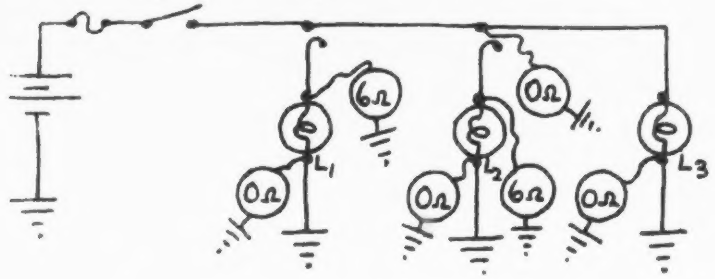
4. ______________________


0Ω
M
M₁
6Ω
M₂
M

Part 3- Opens and Shorts (Ohmmeter)

1. All lights inoperative

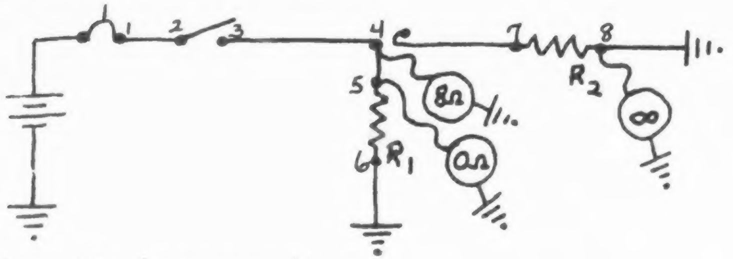
1. ____________________



6Ω
0Ω
L1
0Ω
L2
6Ω
0Ω
0Ω
L3

2. R₂ inoperative

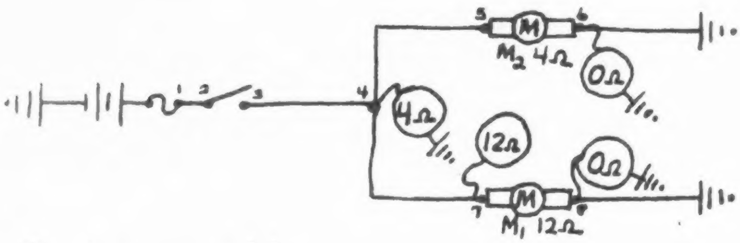
2. ____________________



1
2
3
4
7
8
5
8Ω
R2
∞
6
R1
0Ω

3. M₁ inoperative

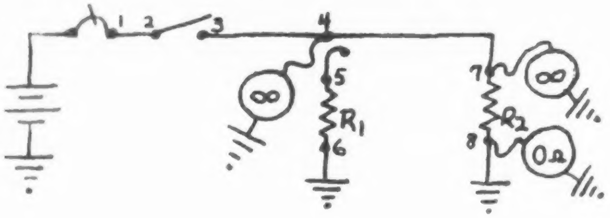
3. ____________________



5
M
6
M2 4Ω
0Ω
1
2
3
4
4Ω
12Ω
0Ω
7
M
8
M1 12Ω

4. R₂ inoperative

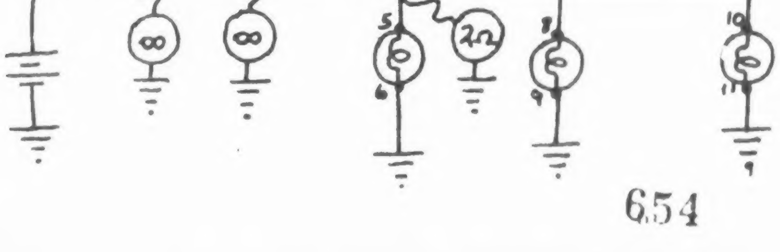
4. ____________________



1
2
3
4
5
∞
R1
6
7
∞
R2
8
0Ω

5. All lights inoperative

5. ____________________

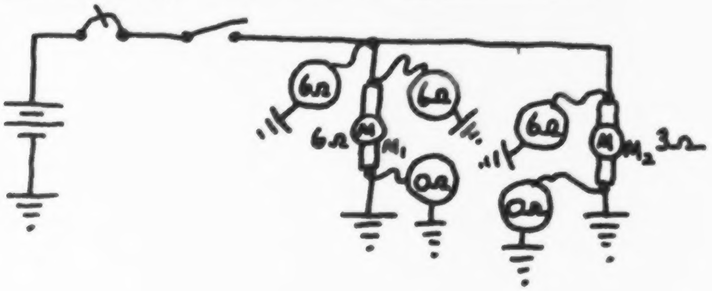


1
2
3
4
7
∞
∞
5
2Ω
8
10
6
9
11

Part 4 - Opens and Shorts (Volt and Ohmmeter)

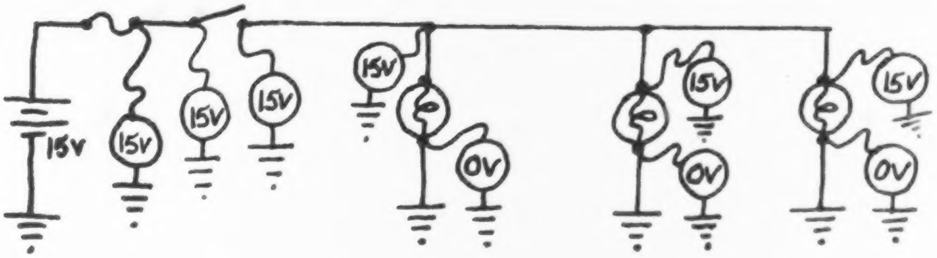
1. M_2 inoperative

1. ______________________


6Ω
6Ω
6Ω
M
M_1
0Ω
6Ω
M
M_2
3Ω
0Ω

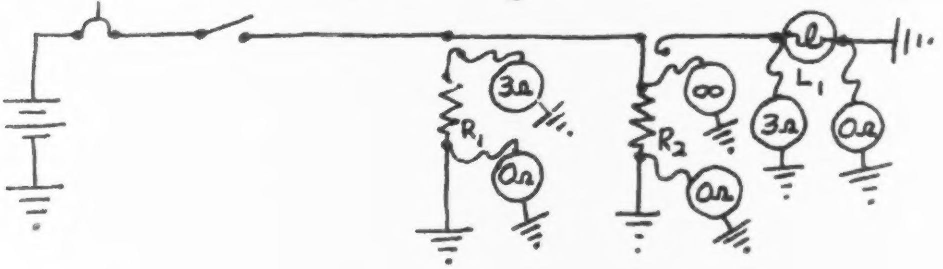
2. Lights will not turn off

2. ______________________


15V
15V
15V
15V
15V
0V
15V
0V
15V
0V

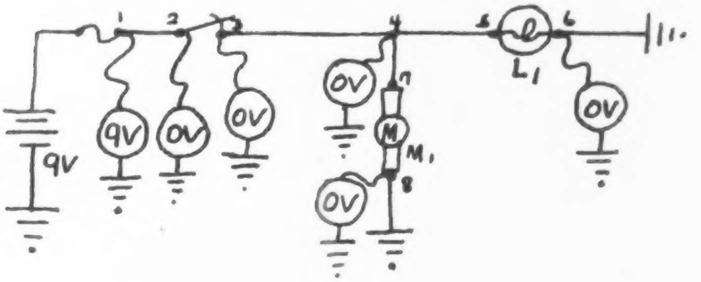
3. R_2 will not drop voltage

3. ______________________


3Ω
R_1
0Ω
∞
R_2
0Ω
L_1
3Ω
0Ω

4. All loads do not work

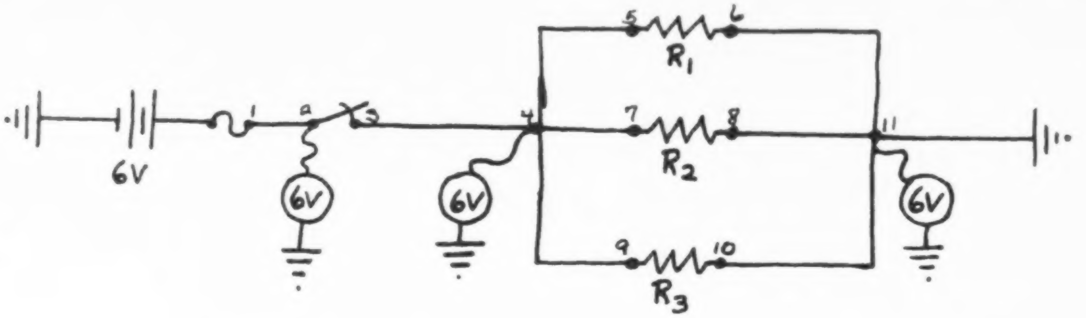
4. ______________________


1
2
3
4
5
6
7
8
9V
9V
0V
0V
0V
M
M_1
0V
L_1
0V

Part 4 (Con't)

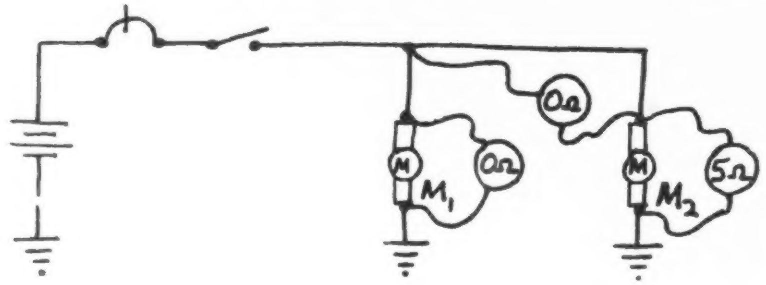
5. Resistors won't work

5. ______________________________


6V
1
2
3
4
5
6
R1
7
8
R2
9
10
R3
11
6V
6V
6V

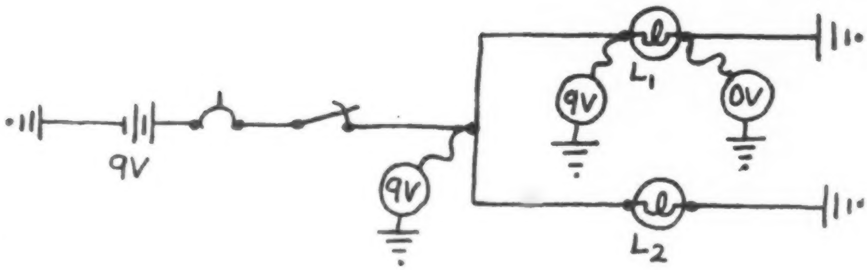
6. Motors will not work

6. ______________________________


0Ω
M
M1
0Ω
M
M2
5Ω

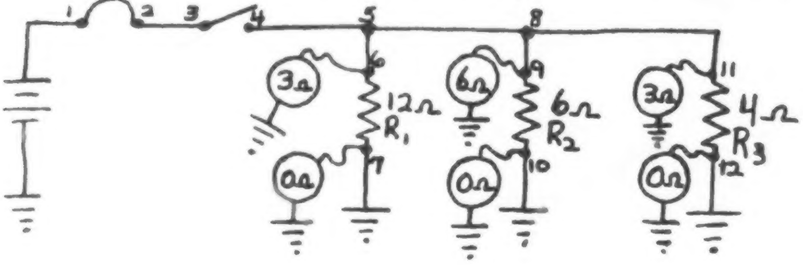
7. L_1 will not light

7. ______________________________


9V
9V
9V
L1
0V
L2

8. R_2 will not drop voltage

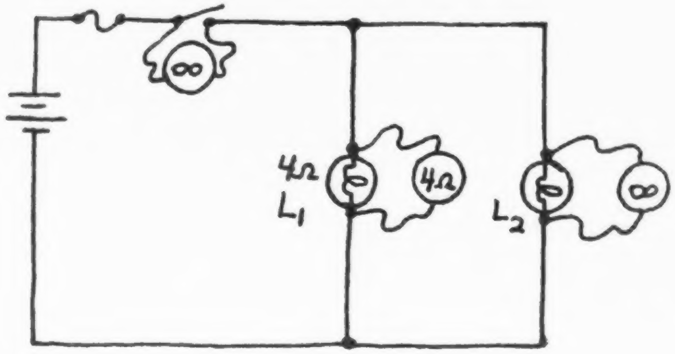
8. ______________________________


1
2
3
4
5
8
6
9
11
3Ω
12Ω
R1
6Ω
6Ω
R2
3Ω
4Ω
R3
7
10
12
0Ω
0Ω
0Ω

Part 4 - (Con't)

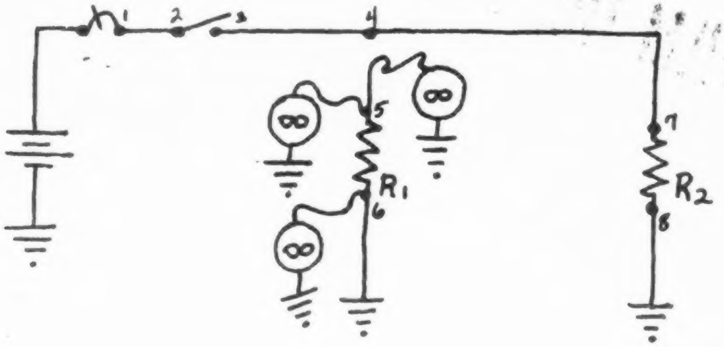
9. L_2 won't light

9. ______________________________



10. R_1 inoperative

10. ______________________________



1
2
3
4
5
6
7
8
R_1
R_2
∞

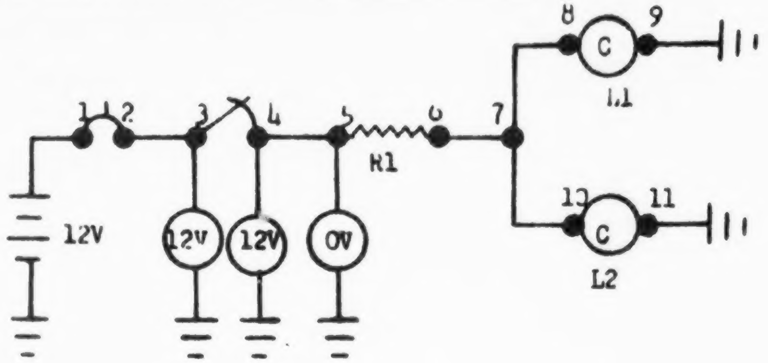
657

Environmental Pneudraulics Branch
Chanute AFB, Illinois

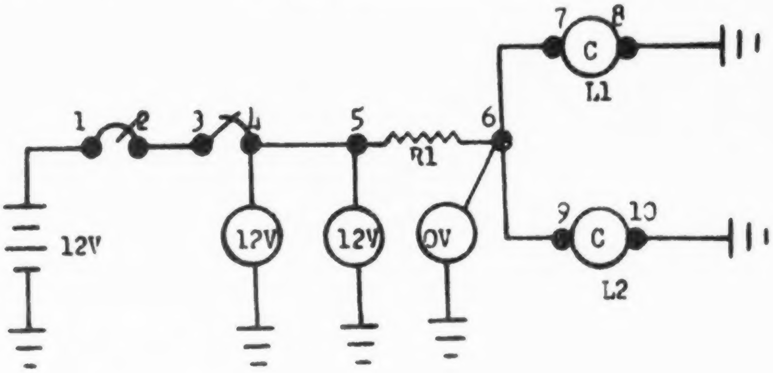
C3ABR42331-HO-114C
22 August 1984

SERIES PARALLEL TROUBLESHOOTING

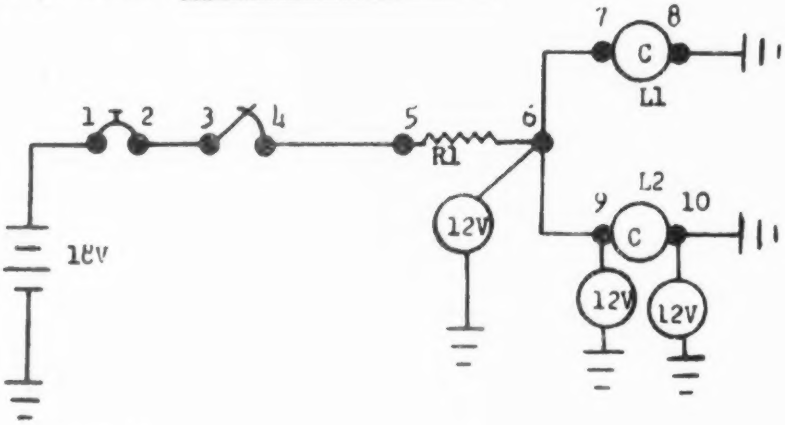
1. Both lamps inoperative. ____________________


1
2
3
4
5
6
7
8
9
10
11
C
C
L1
L2
R1
12V
12V
12V
0V

2. Both lamps inoperative ____________________


1
2
3
4
5
6
7
8
9
10
C
C
L1
L2
R1
12V
12V
12V
0V

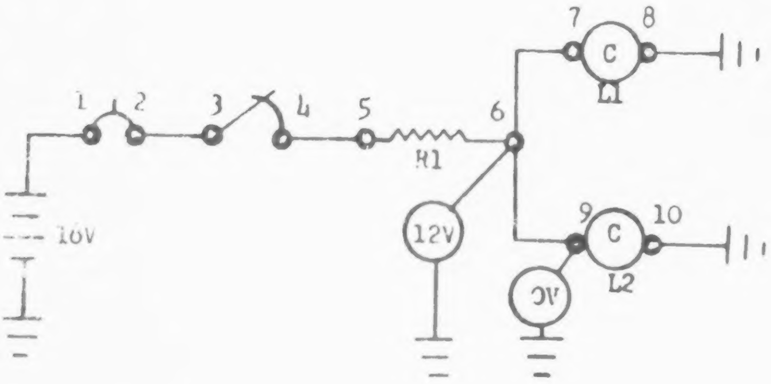
3. L_2 is inoperative. ____________________


1
2
3
4
5
6
7
8
9
10
C
C
L1
L2
R1
12V
12V
12V
12V

DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

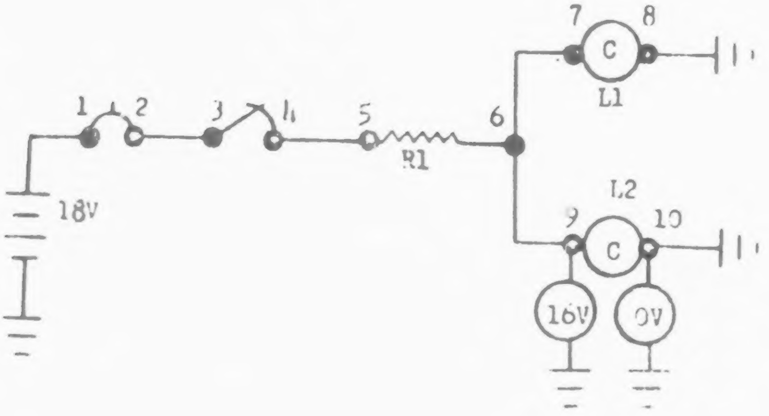
Designed for ATC Course Use. Do Not Use on the Job.

4. L_2 is inoperative. ______________________



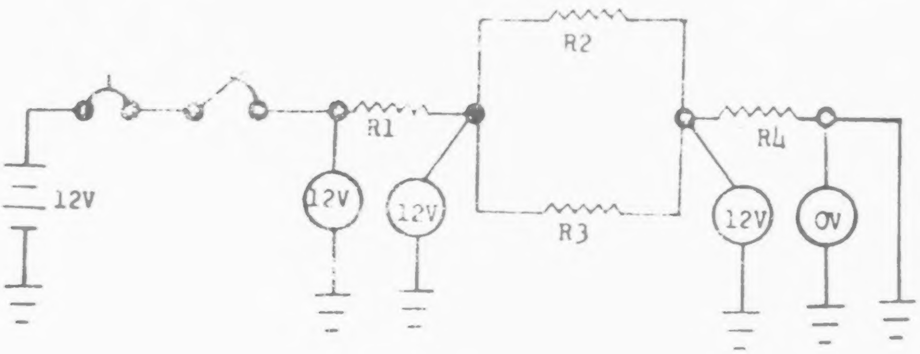
1
2
3
4
5
R1
6
7
8
C
L1
9
10
C
L2
16V
12V
0V

5. L_2 is inoperative. ______________________



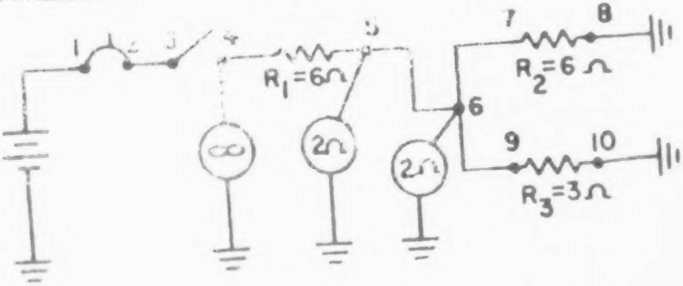
1
2
3
4
5
R1
6
7
8
C
L1
L2
9
10
C
18V
16V
0V

6. ______________________

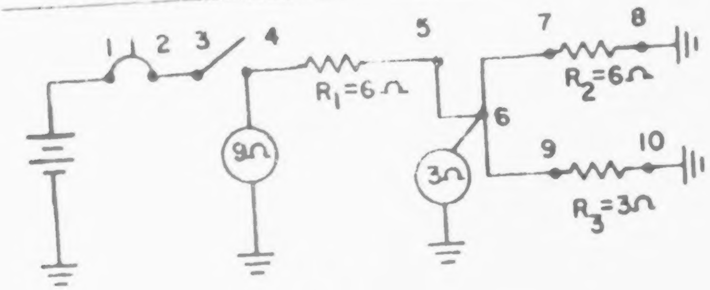


R2
R1
R3
R4
12V
12V
12V
12V
0V

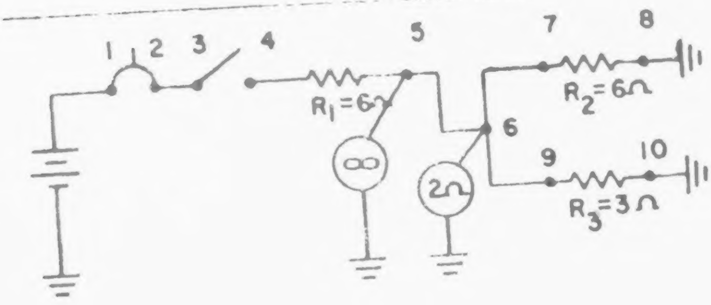
1. ______________________


R$_1$=6Ω
R$_2$=6Ω
R$_3$=3Ω
∞
2Ω
2Ω

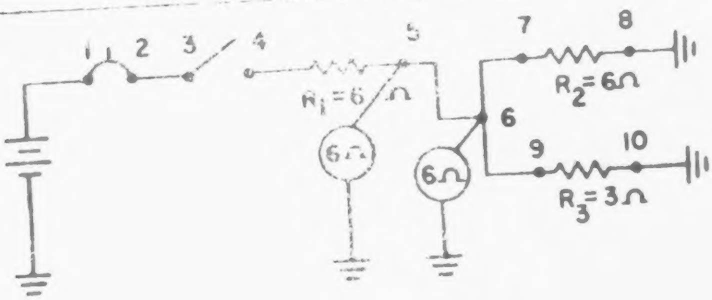
2. ______________________


R$_1$=6Ω
R$_2$=6Ω
R$_3$=3Ω
9Ω
3Ω

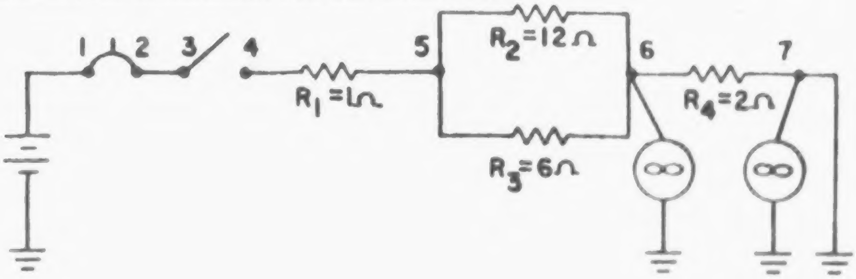
3. ______________________


R$_1$=6Ω
R$_2$=6Ω
R$_3$=3Ω
∞
2Ω

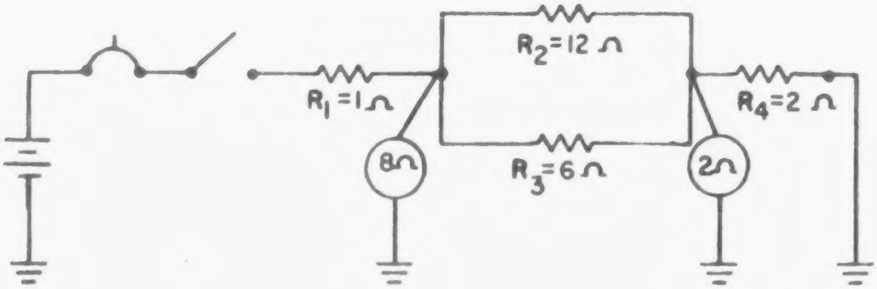
4. ______________________


R$_1$=6Ω
R$_2$=6Ω
R$_3$=3Ω
6Ω
6Ω

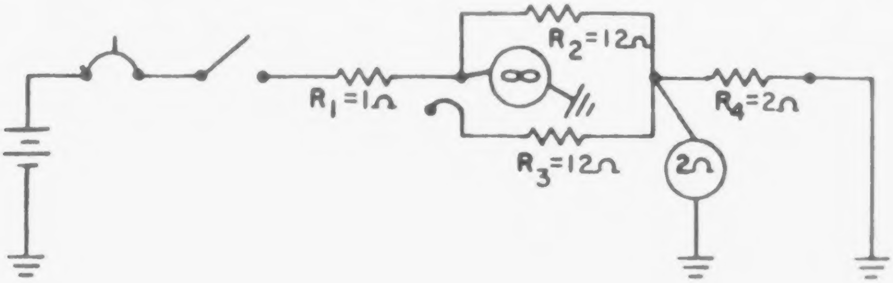
5. ____


1
2
3
4
5
6
7
R2=12Ω
R1=1Ω
R4=2Ω
R3=6Ω
∞
∞

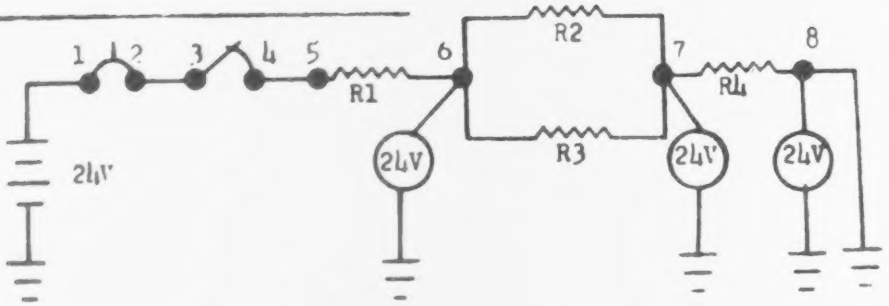
6. ____


R2=12 Ω
R1=1 Ω
R4=2 Ω
8Ω
R3=6 Ω
2Ω

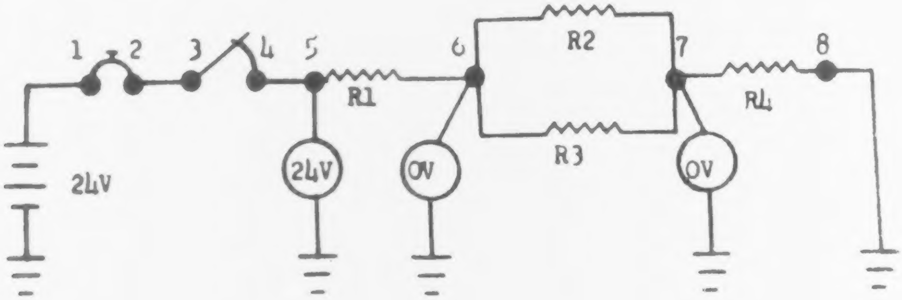
7. ____


R2=12Ω
∞
R1=1Ω
R4=2Ω
R3=12Ω
2Ω

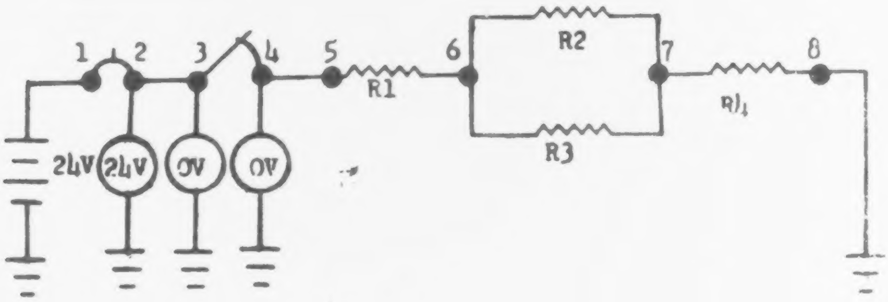
1. ____________________________________


1
2
3
4
5
6
7
8
R1
R2
R3
R4
24V
24V
24V
24V

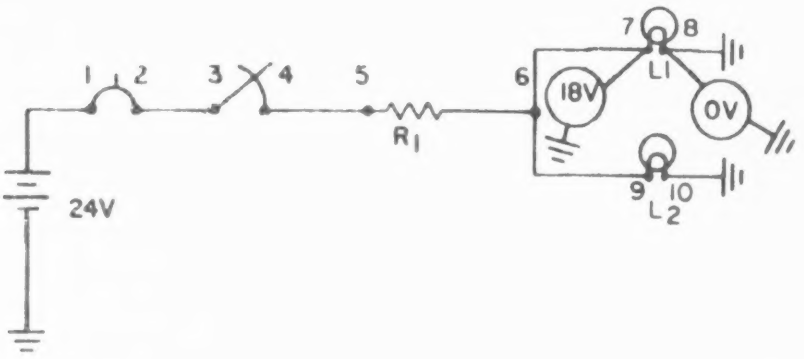
2. ____________________________________


1
2
3
4
5
6
7
8
R1
R2
R3
R4
24V
24V
OV
OV

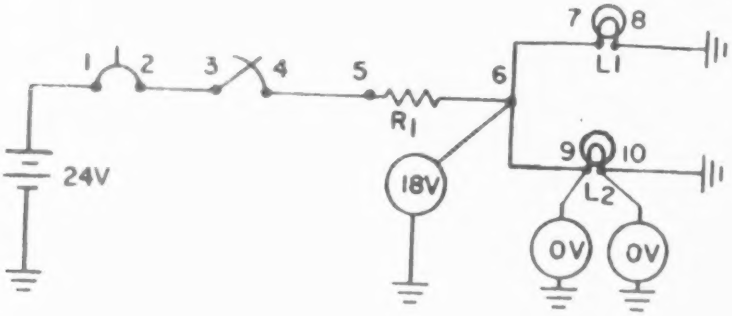
3. ____________________________________


1
2
3
4
5
6
7
8
R1
R2
R3
R4
24V
24V
OV
OV

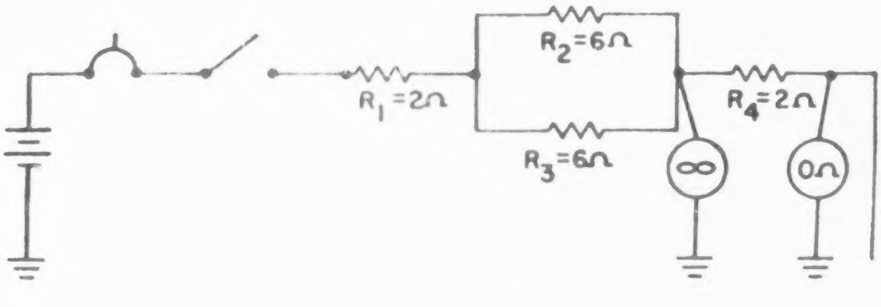
4. L_1 is inoperative. ____________________


1
2
3
4
5
6
7
8
L1
18V
0V
R1
9
10
L2
24V

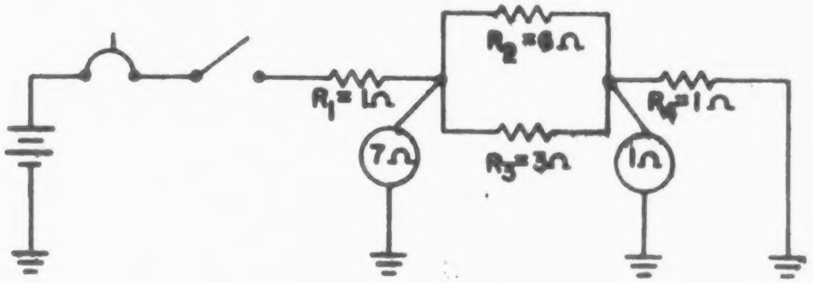
5. L_2 is inoperative. ____________________


7
8
L1
1
2
3
4
5
6
R1
9
10
L2
24V
18V
0V
0V

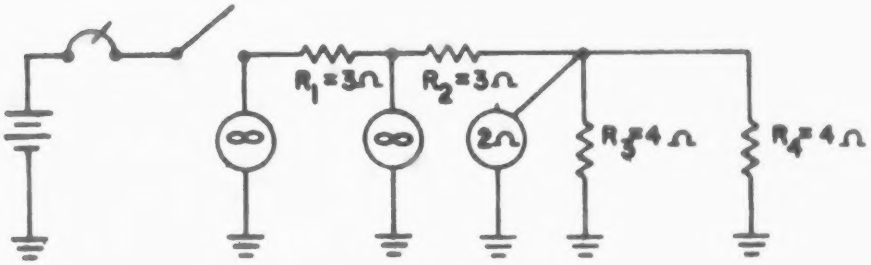
6. ____________________________________


R2=6Ω
R1=2Ω
R4=2Ω
R3=6Ω
∞
0Ω

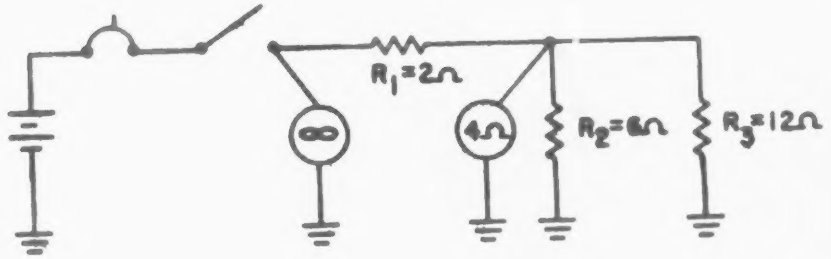
7. ______________________________


$R_2 = 6\Omega$
$R_1 = 1\Omega$
$R_4 = 1\Omega$
7Ω
$R_3 = 3\Omega$
1Ω

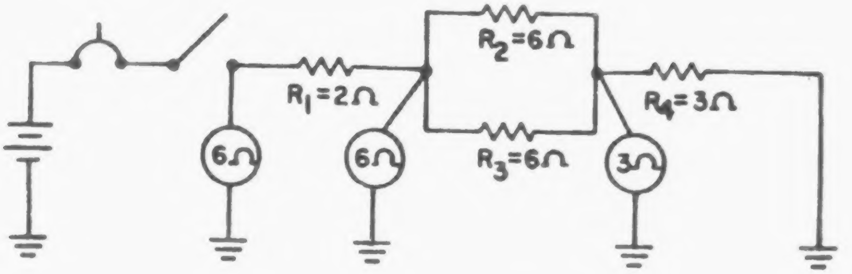
8. ______________________________


$R_1 = 3\Omega$
$R_2 = 3\Omega$
∞
∞
2Ω
$R_3 = 4\Omega$
$R_4 = 4\Omega$

9. ______________________________

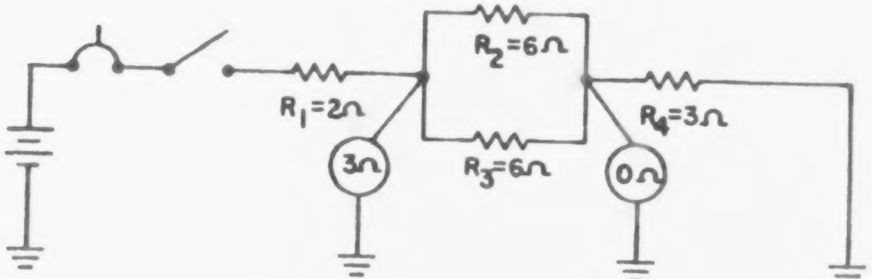

$R_1 = 2\Omega$
∞
4Ω
$R_2 = 6\Omega$
$R_3 = 12\Omega$

1. ______________________________



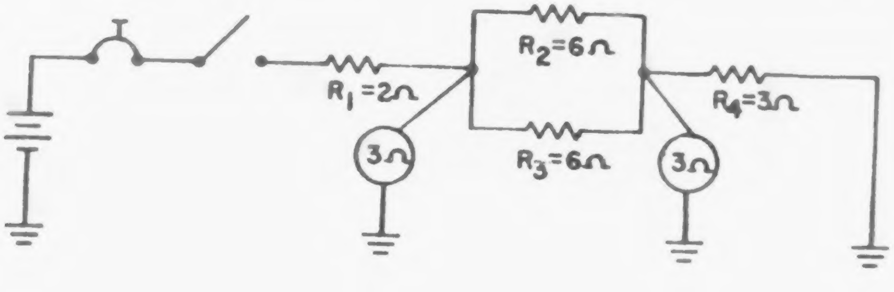
$R_2=6\Omega$
$R_1=2\Omega$
$R_4=3\Omega$
$R_3=6\Omega$
6Ω
6Ω
3Ω

2. ______________________________



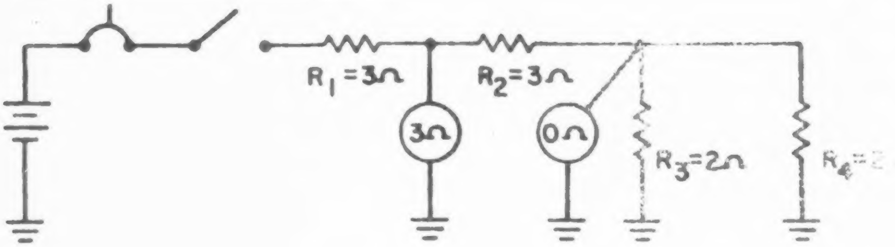
$R_2=6\Omega$
$R_1=2\Omega$
$R_4=3\Omega$
$R_3=6\Omega$
3Ω
0Ω

3. ______________________________



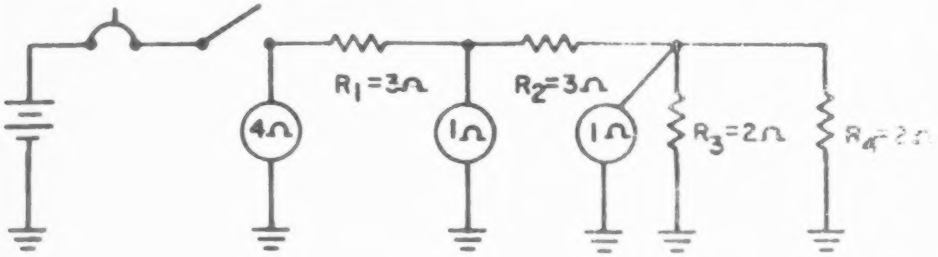
$R_2=6\Omega$
$R_1=2\Omega$
$R_4=3\Omega$
$R_3=6\Omega$
3Ω
3Ω

4. ________________________



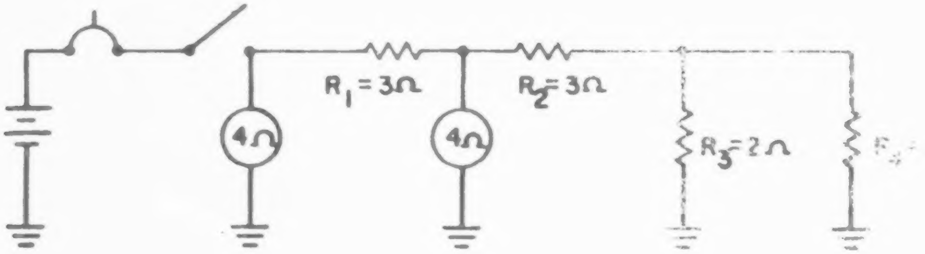
$R_1 = 3\Omega$
$R_2 = 3\Omega$
3Ω
0Ω
$R_3 = 2\Omega$
$R_4 = 2$

5. ________________________



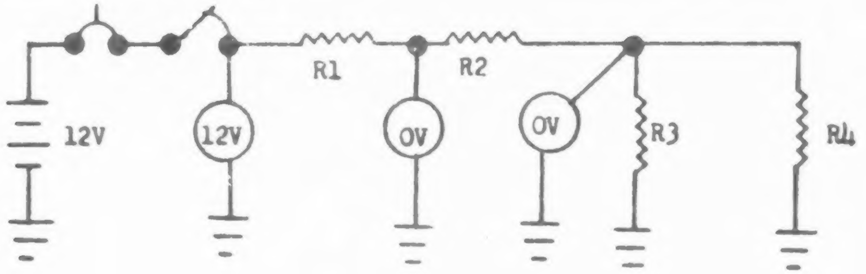
4Ω
$R_1 = 3\Omega$
1Ω
$R_2 = 3\Omega$
1Ω
$R_3 = 2\Omega$
$R_4 = 2\Omega$

6. ________________________



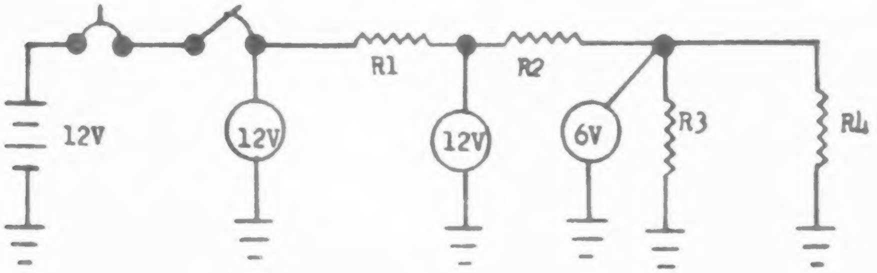
4Ω
$R_1 = 3\Omega$
4Ω
$R_2 = 3\Omega$
$R_3 = 2\Omega$
R_4

1. ______________________________



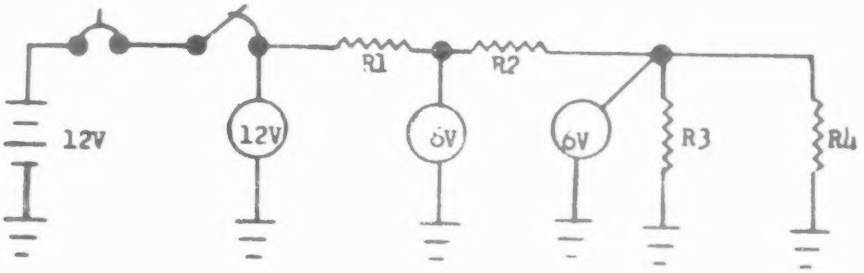
12V
12V
R1
0V
R2
0V
R3
R4

2. ______________________________



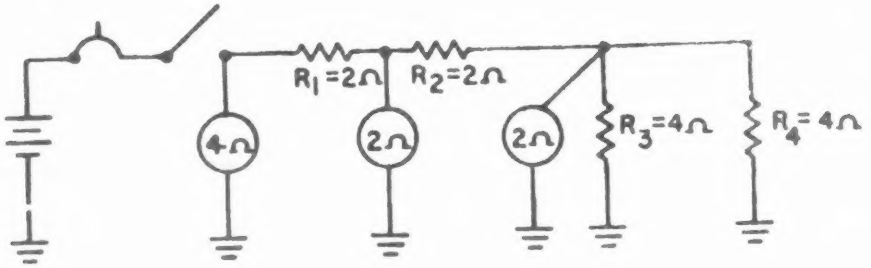
12V
12V
R1
12V
R2
6V
R3
R4

3. ______________________________



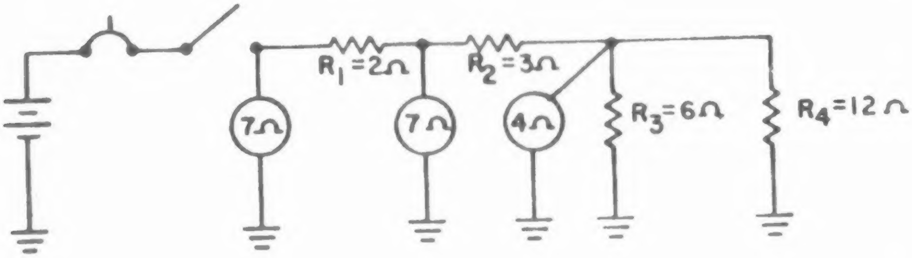
12V
12V
R1
6V
R2
6V
R3
R4

4. ______________________________



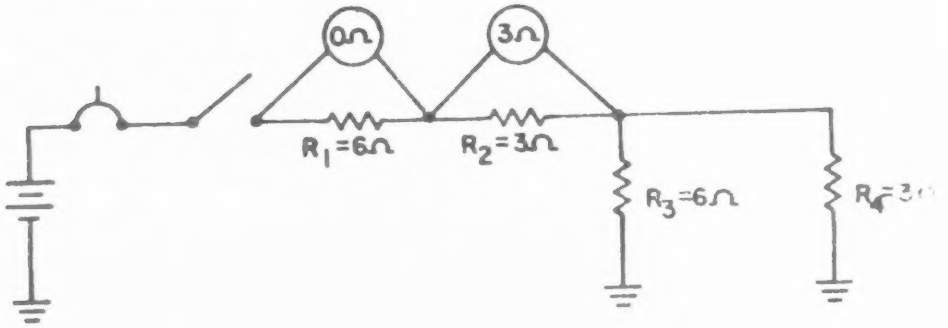
R1=2Ω
R2=2Ω
4Ω
2Ω
2Ω
R3=4Ω
R4=4Ω

5. ______________________________



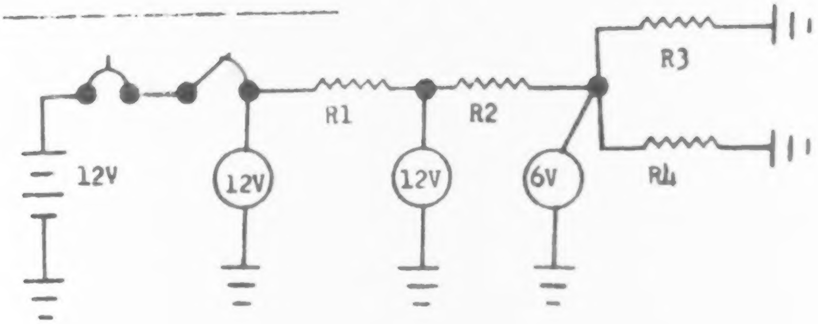
R1=2Ω
R2=3Ω
7Ω
7Ω
4Ω
R3=6Ω
R4=12Ω

6. ______________________________

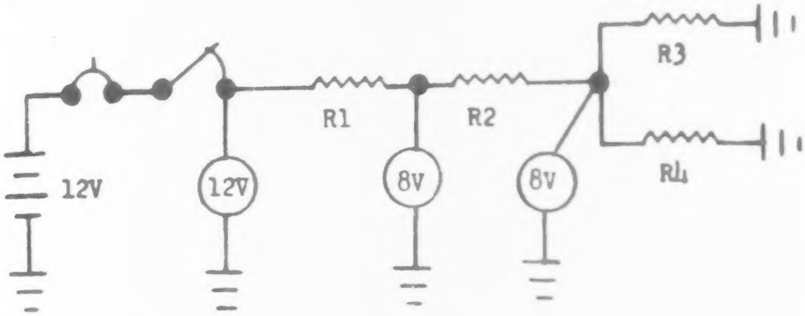


0Ω
3Ω
R1=6Ω
R2=3Ω
R3=6Ω
R4=3

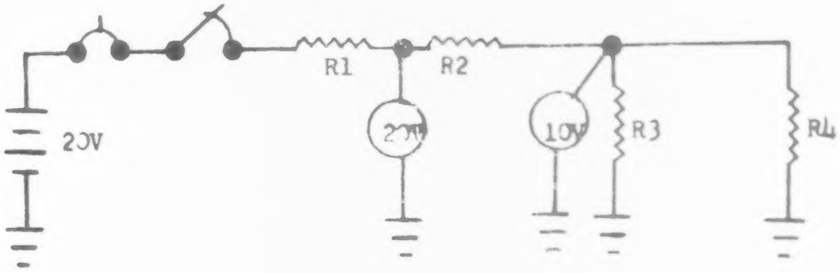
1. ________________________________


12V
12V
R1
12V
R2
6V
R3
R4

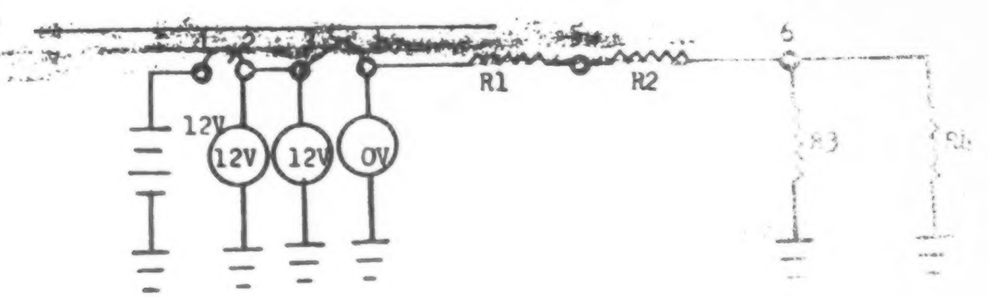
2. ________________________________


12V
12V
R1
8V
R2
8V
R3
R4

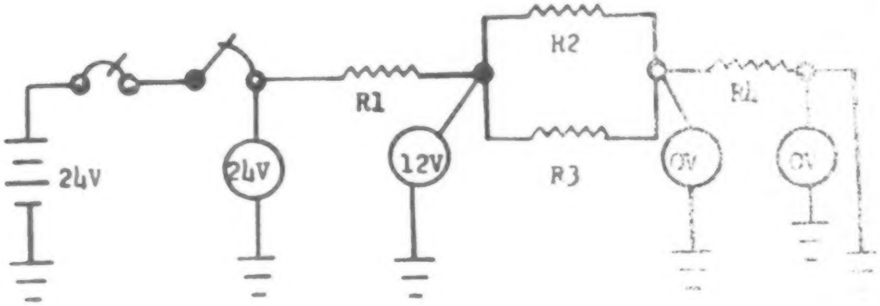
3. ________________________________


20V
R1
20V
R2
10V
R3
R4

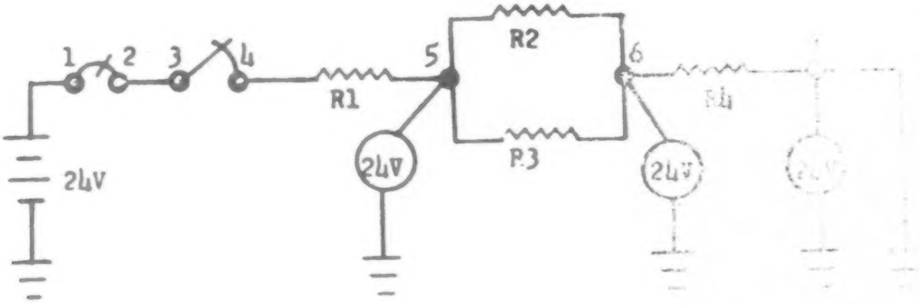
4.


12V
12V
12V
0V
R1
R2
6
R3
R4

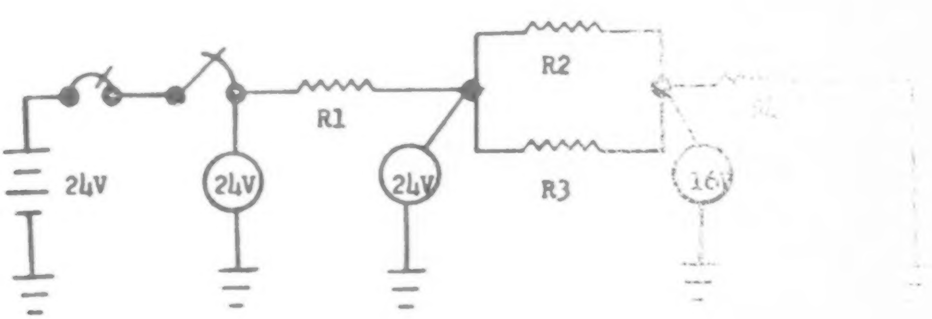
5. ____________________


24V
24V
R1
12V
R2
R3
0V
R4
0V

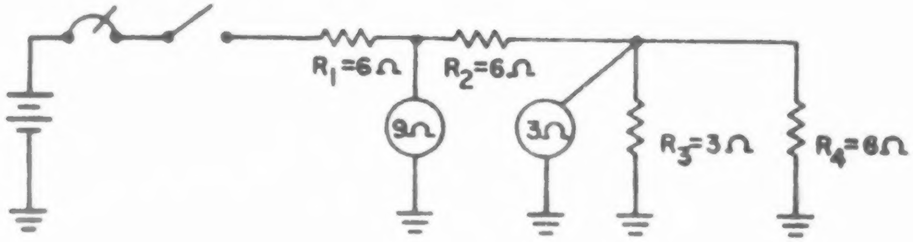
6. ____________________


1
2
3
4
5
6
24V
R1
24V
R2
R3
24V
R4
24V

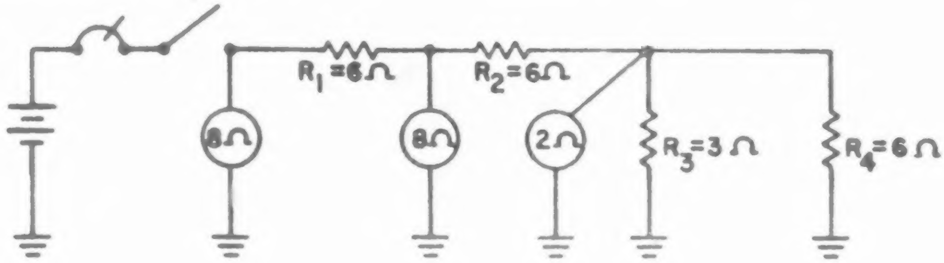
7. ____________________


24V
24V
R1
24V
R2
R3
R4
16V

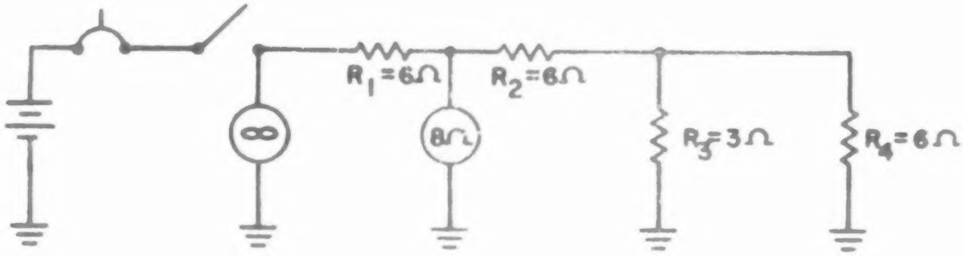
1. ____________________


$R_1=6\Omega$
$R_2=6\Omega$
9Ω
3Ω
$R_3=3\Omega$
$R_4=6\Omega$

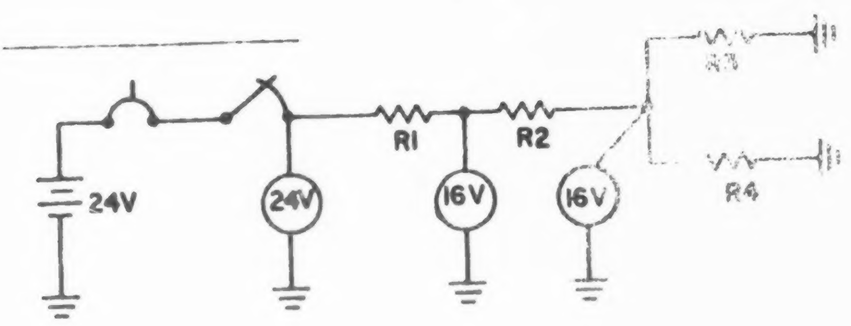
2. ____________________


$R_1=6\Omega$
$R_2=6\Omega$
8Ω
8Ω
2Ω
$R_3=3\Omega$
$R_4=6\Omega$

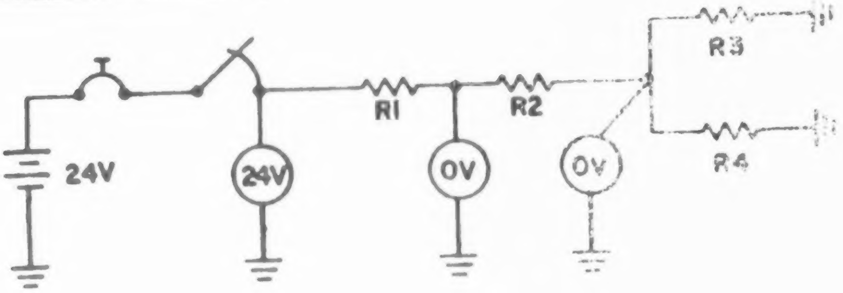
3. ____________________


$R_1=6\Omega$
$R_2=6\Omega$
∞
8Ω
$R_3=3\Omega$
$R_4=6\Omega$

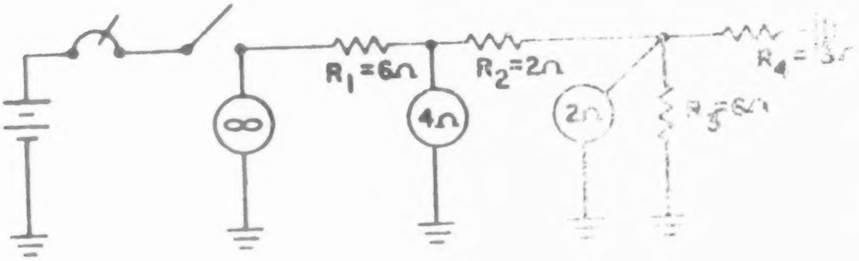
4. ____________________


24V
24V
R1
16V
R2
16V
R3
R4

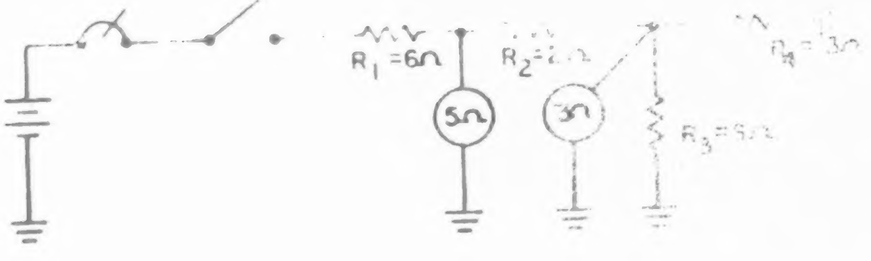
5. ____________________


24V
24V
R1
0V
R2
0V
R3
R4

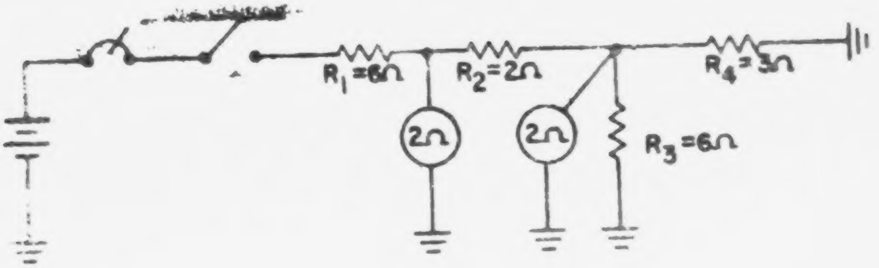
6. ____________________


∞
R1=6Ω
4Ω
R2=2Ω
2Ω
R4=3Ω
R3=6Ω

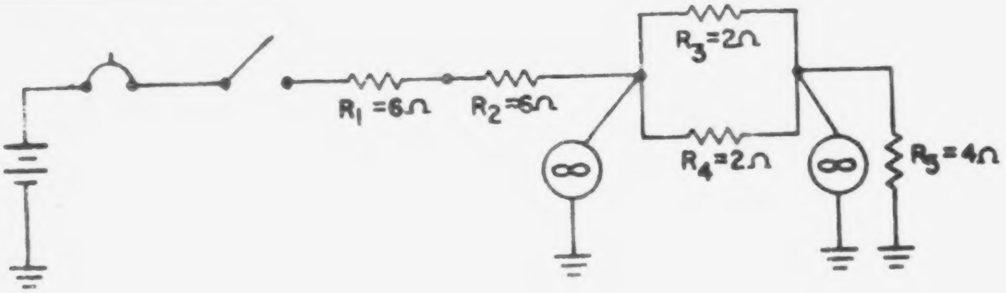
7. ____________________


R1=6Ω
5Ω
R2=2Ω
3Ω
R4=3Ω
R3=6Ω

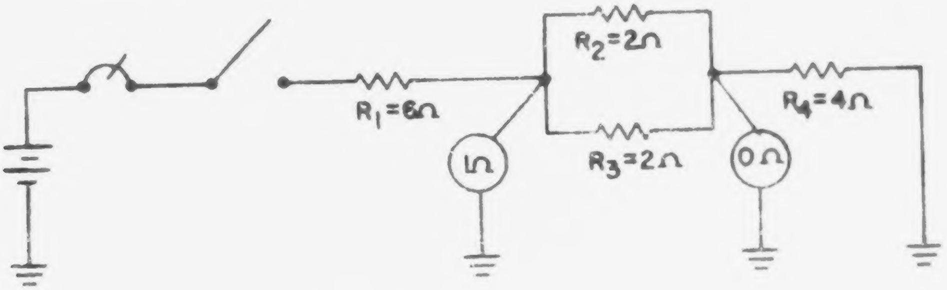
8. ______________________


R₁=6Ω
R₂=2Ω
R₄=3Ω
2Ω
2Ω
R₃=6Ω

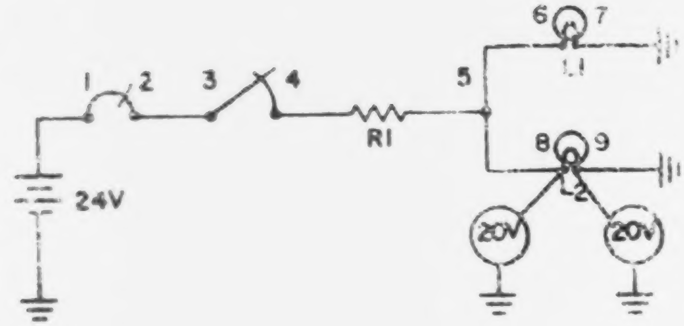
9. ______________________


R₃=2Ω
R₁=6Ω
R₂=6Ω
R₄=2Ω
∞
∞
R₅=4Ω

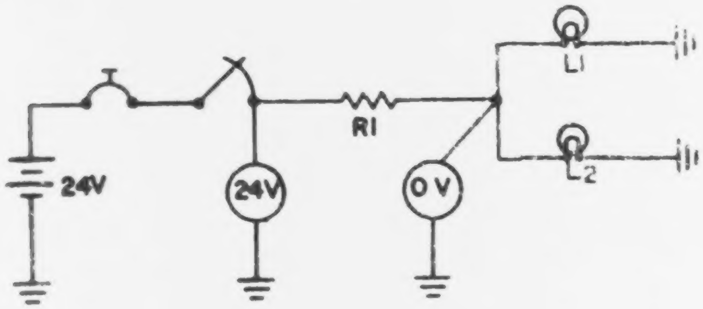
10. ______________________


R₂=2Ω
R₁=6Ω
R₄=4Ω
1Ω
R₃=2Ω
0Ω

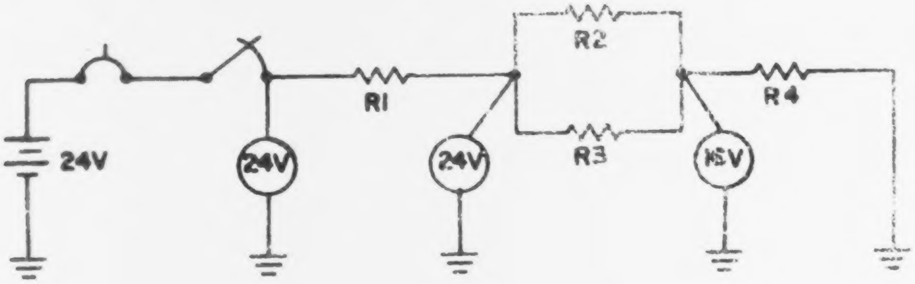
[illegible] is inoperative. ______________________


1
2
3
4
5
6
7
L1
R1
8
9
L2
24V
20V
20V

2. Both lamps inoperative. ________________


L1
R1
L2
24V
24V
0 V

3. ________________


R2
R1
R4
R3
24V
24V
24V
16V

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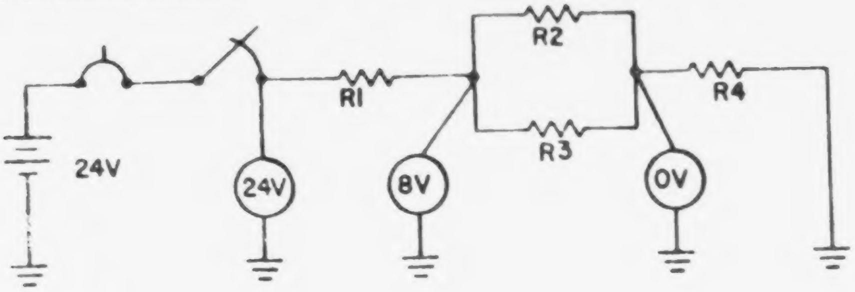
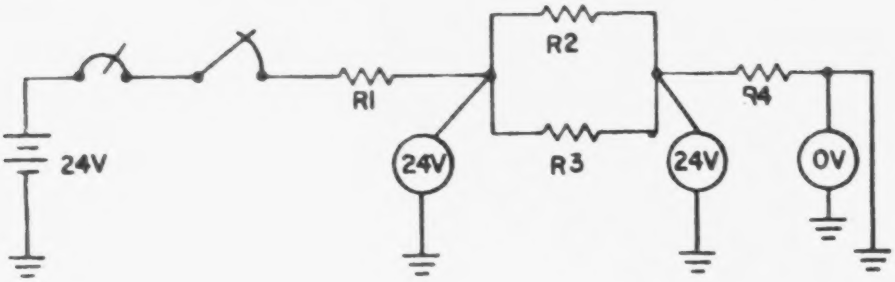
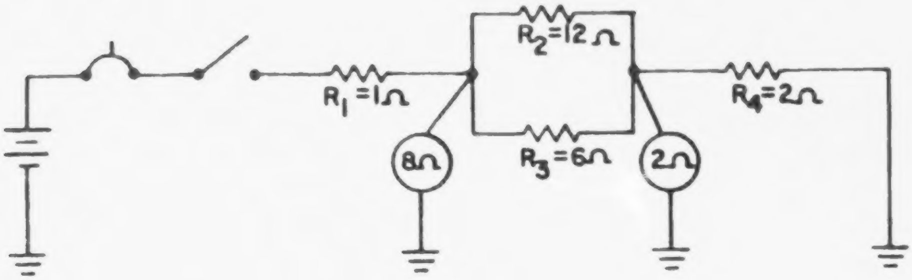
4. ____________________


R2
R1
R4
R3
24V
24V
8V
0V

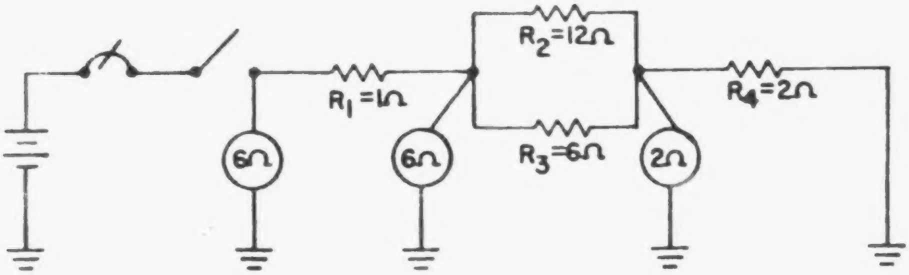
5. ____________________

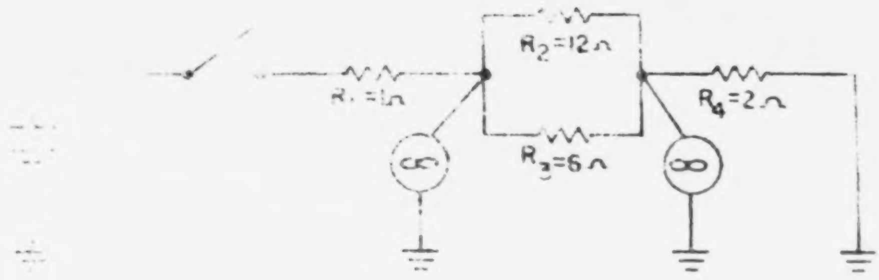

R2
R1
R4
24V
24V
R3
24V
0V

6. ____________________

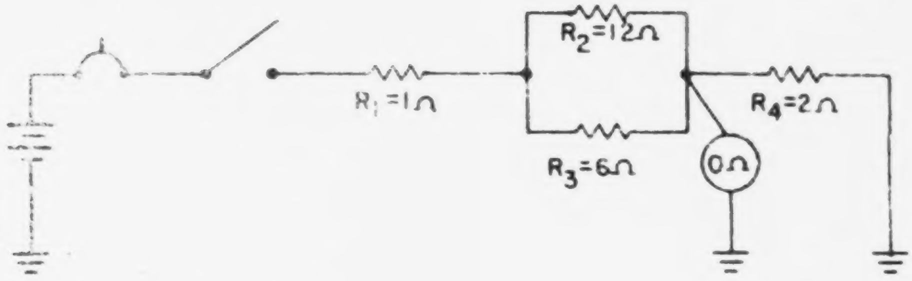

$R_2=12\Omega$
$R_1=1\Omega$
$R_4=2\Omega$
8Ω
$R_3=6\Omega$
2Ω

7. ____________________

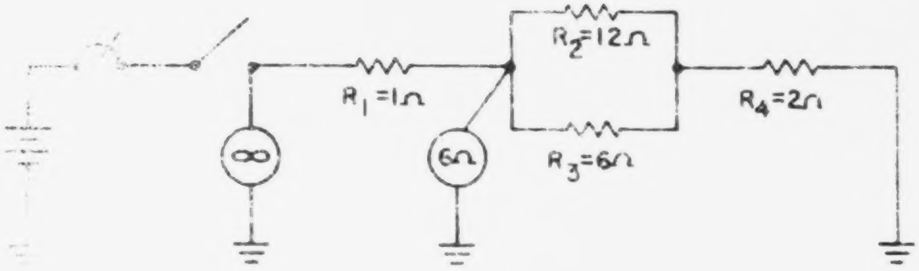

$R_2=12\Omega$
$R_1=1\Omega$
$R_4=2\Omega$
6Ω
6Ω
$R_3=6\Omega$
2Ω


R₂=12Ω
R₁=1Ω
R₄=2Ω
R₃=6Ω
∞
∞

9. ______________________


R₂=12Ω
R₁=1Ω
R₄=2Ω
R₃=6Ω
0Ω

10. ______________________


R₂=12Ω
R₁=1Ω
R₄=2Ω
R₃=6Ω
∞
6Ω

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PROGRAMMED TEXT
3ABR42331-PT-115

Technical Training

Aircraft Environmental Systems Mechanic

KIRCHHOFF'S VOLTAGE LAW

20 February 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

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RGL: 9.2

OBJECTIVE

Use Kirchhoff's voltage law to solve for unknown voltage values in basic electrical circuits. A minimum of eight out of ten unknown values must be correct.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." Carefully study the written material and or diagram in each frame until you are satisfied that you understand its contents. Each frame requires you to respond to the information in some way. For example, you may be required to solve for unknowns in circuits. Specific instructions are provided in each frame. After you have made your response in this book, compare your answers with the answers given on the top of the next page of the text. If you are correct, go on to the next frame. If you are incorrect, study the frame again and correct your mistakes before continuing. Read carefully, select the correct answers and DO NOT HURRY.

INTRODUCTION

In your last lesson you learned how to apply Kirchhoff's current law in solving for unknowns in a circuit. This lesson is designed to familiarize you with Kirchhoff's voltage law and to show how to apply it to actual circuits.

Supersedes 3ABR42331-PT-115, 7 March 1980.
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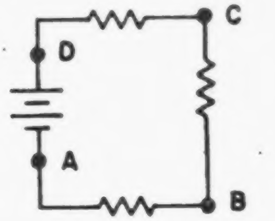
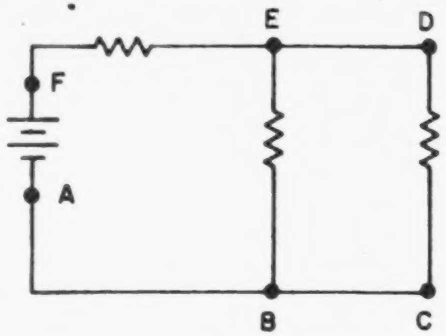
Frame 1

Kirchhoff's voltage law is stated as follows: The sum of the voltage drops around any closed path is equal to the total voltage applied to that path. In order to use this law you must understand what is meant by a closed path. To explain this we will use the examples shown below. Example A has just one closed path. It is point A-B-C-D. In example B there are two closed paths. One path is point A-B-E-F. The other path goes from point A-B-C-D-E-F. Trace these two paths in example B to be sure that you understand that there are two closed paths.



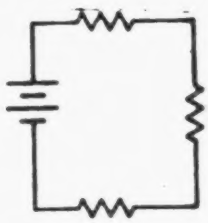
A.



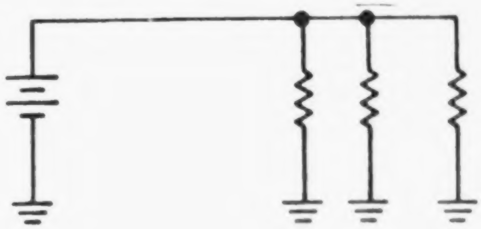
B.

For each of the following circuits indicate in the blanks provided how many closed paths each circuit has.

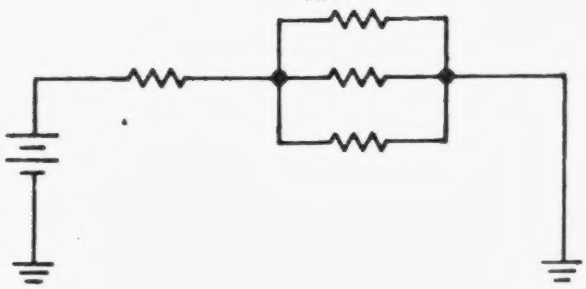
1. How many paths? ________



2. How many paths? ________



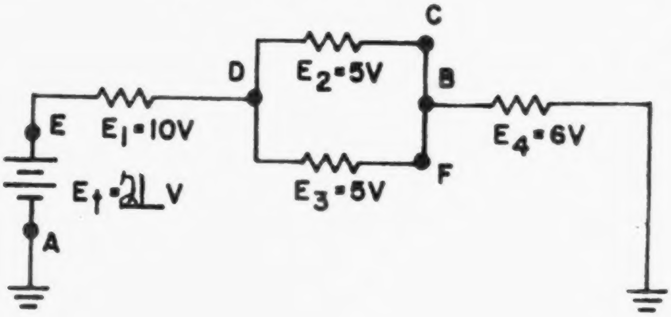
3. How many paths? ________



Answers to Frame 1: 1. __1__ 2. __3__ 3. __3__

Frame 2

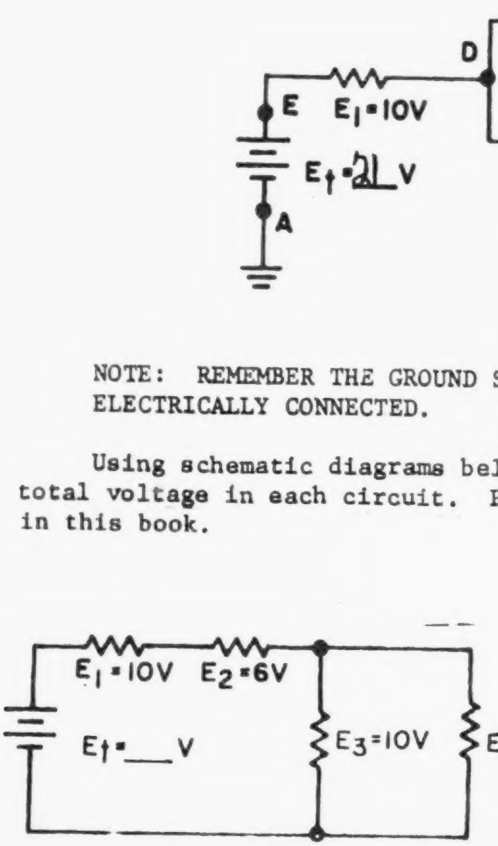
Now that you know how to determine the closed paths in a circuit, we will show you how to use Kirchhoff's voltage law to determine unknown voltages. First, we'll restate Kirchhoff's voltage law. The sum of the voltage drops around any closed path is equal to the total voltage applied to that path. To show this we will use the circuit shown below. This figure has two paths. Let's first use the path: A-B-C-D-E. Adding up the voltage drops in this path we have, $E_4 + E_2 + E_1 = 6V + 5V + 10V = 21V$. Kirchhoff's voltage law states that the sum of the drops around any closed path is equal to the total voltage applied. Thus, $E_t = 21V$. Now let's use the other path. It is as follows: A-B-F-D-E. Adding up the voltage drops in this path we have $E_4 + E_3 + E_1 = 6V + 5V + 10V = 21V$. Thus, $E_t = 21V$. As you can see it didn't matter which path we used, we found $E_t = 21V$ using either path. The important thing to remember is to add up the voltage drops around only ONE closed path.



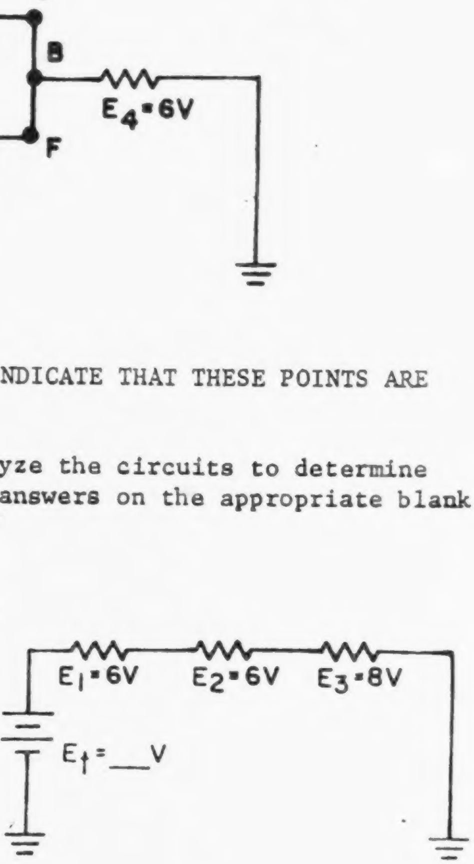
NOTE: REMEMBER THE GROUND SYMBOLS INDICATE THAT THESE POINTS ARE ELECTRICALLY CONNECTED.

Using schematic diagrams below, analyze the circuits to determine total voltage in each circuit. Put your answers on the appropriate blank in this book.

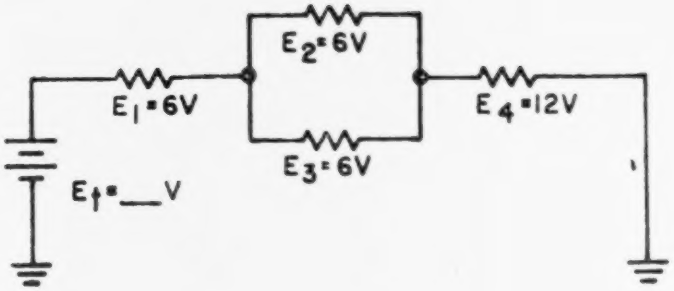
1.



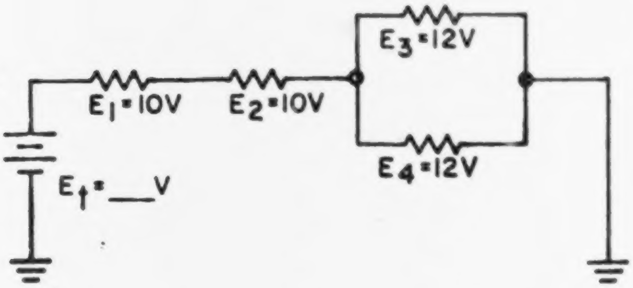
2.



3.


E₁=6V
E₂=6V
E₃=6V
E₄=12V
Eₜ=__V

4.

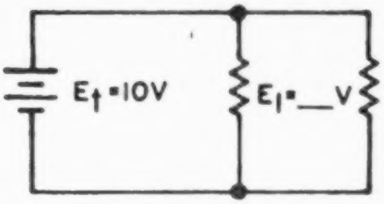

E₁=10V
E₂=10V
E₃=12V
E₄=12V
Eₜ=__V

Answers to Frame 2: 1. 26V 2. 20V 3. 24V 4. 32V

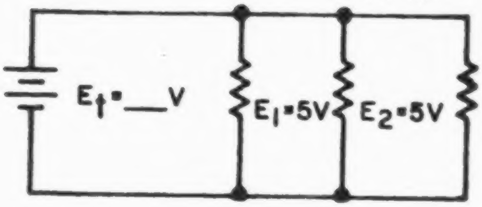
Frame 3

Using the schematic diagrams below, analyze the circuits to determine the unknown voltage in each circuit. Put your answers on the appropriate blank. Remember the total voltage is the sum of the voltage in only one close path.

1.



2.



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Answers to Frame 3: 1. 10V 2. 5V

Frame 4

In the past frames you saw that Kirchhoff's voltage law is true in actual circuits. The rest of this lesson will give you practice applying Kirchhoff's voltage law. First, we'll give you one more example problem that is worked out step by step. There are two closed paths in the circuit below. One path is A-B-C-D-E.

Applying Kirchhoff's voltage law to this path we have $E_{R4} + E_{R2} + E_{R1} = 30V$. Substituting in known values we have $E_{R4} + E_{R2} + 10V = 30V$. Since there are two unknown voltage drops in this path, we cannot determine the value of either E_{R4} or E_{R2} by using this path. We must use a path that has only one unknown voltage in it. The other path is A-B-F-D-E. Note that this path has only one unknown in it. Applying Kirchhoff's voltage law to this path we have $E_{R4} + E_{R3} + E_{R1} = 30V$. Substituting in known values we have $E_{R4} + 12V + 10V = 30V$. Thus, $E_{R4} = 8V$. Fill in 8V for E_{R4} in the circuit below. Now we have enough information to find E_{R2}. Applying Kirchhoff's voltage law to the path, A-B-C-D-E, we have $E_{R4} + E_{R2} + E_{R1} = E_t$. Substituting in known values we have $8V + E_{R2} + 10V = 30V$. Thus, $E_{R2} = 12V$.

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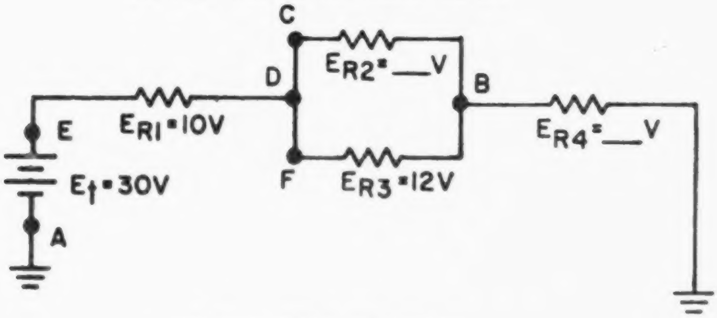

NO RESPONSE REQUIRED

Proceed to the next frame.

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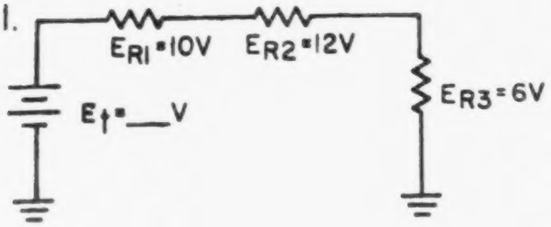
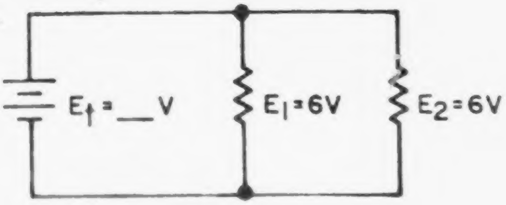
Frame 5

Using Kirchhoff's voltage law, analyze the circuits below to determine the unknown voltage in each circuit. Put your answers on the appropriate blank.

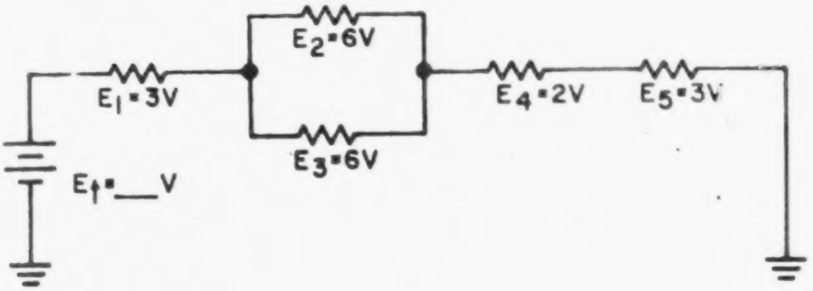
1.


E_{R1} = 10V
E_{R2} = 12V
E_{R3} = 6V
E_t = __V

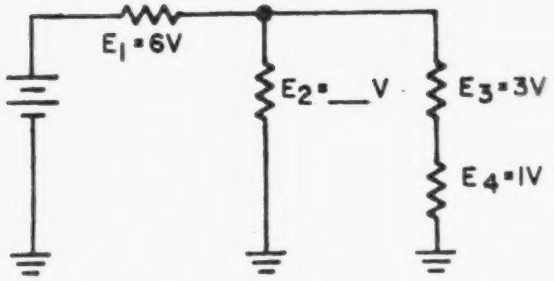
2.


E_t = __V
E_1 = 6V
E_2 = 6V

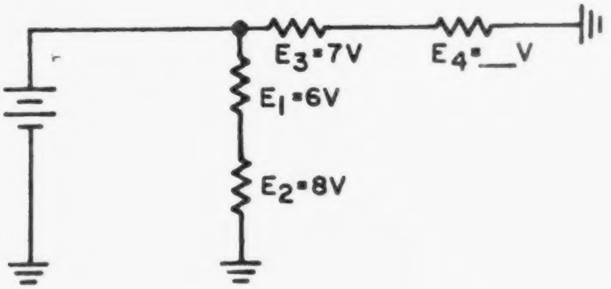
3.


E_1 = 3V
E_2 = 6V
E_3 = 6V
E_4 = 2V
E_5 = 3V
E_t = __V

4.


E_1 = 6V
E_2 = __V
E_3 = 3V
E_4 = 1V

5.


E_3 = 7V
E_4 = __V
E_1 = 6V
E_2 = 8V

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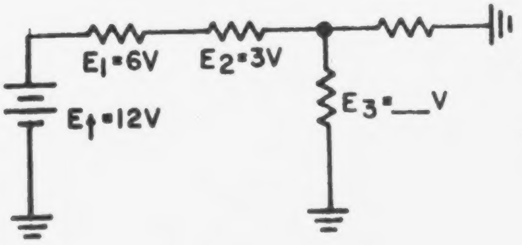
Answers to Frame 5: 1. 28V 2. 6V 3. 14V 4. 4V 5. 7V

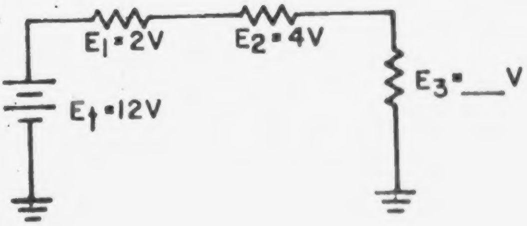
Frame 6

Using Kirchhoff's voltage law, analyze the circuits below to determine the unknown voltage in each circuit. Put your answers on the appropriate blank.

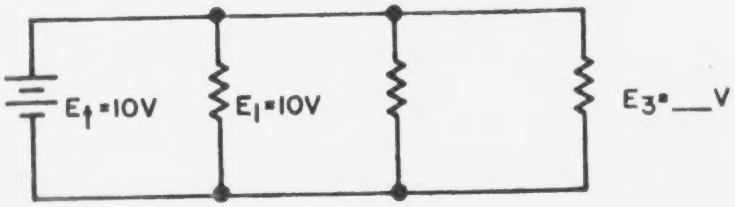
1.


E_1=6V
E_2=3V
E_t=12V
E_3=__V

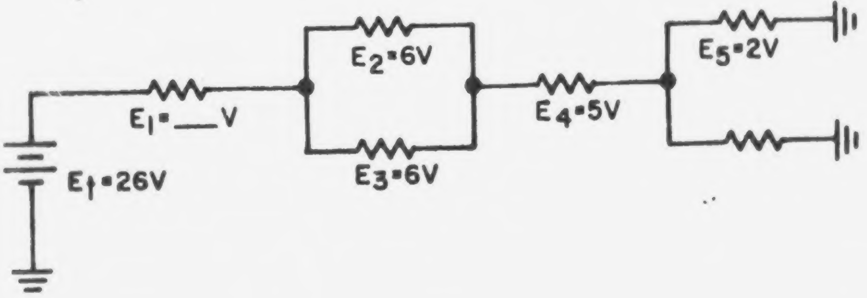
2.


E_1=2V
E_2=4V
E_t=12V
E_3=__V

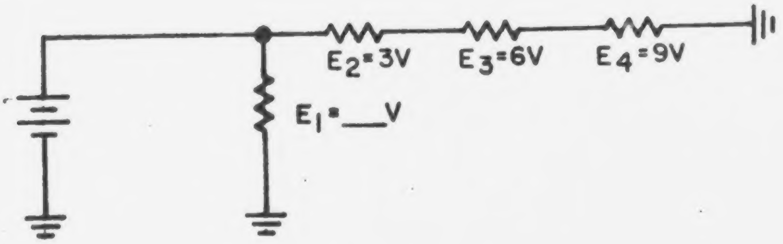
3.


E_t=10V
E_1=10V
E_3=__V

4.


E_1=__V
E_2=6V
E_3=6V
E_4=5V
E_5=2V
E_t=26V

5.

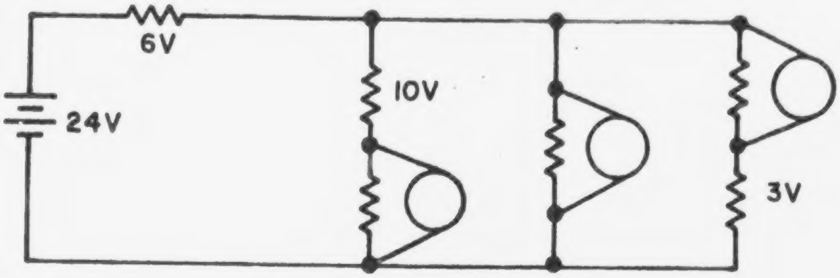

E_2=3V
E_3=6V
E_4=9V
E_1=__V

Answers to Frame 6: 1. 3V 2. 6V 3. 10V 4. 13V 5. 18V

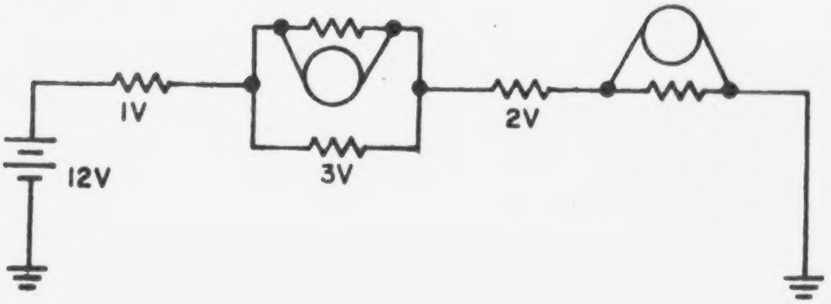
Frame 7

Fill in the voltmeter readings in the circuits below.

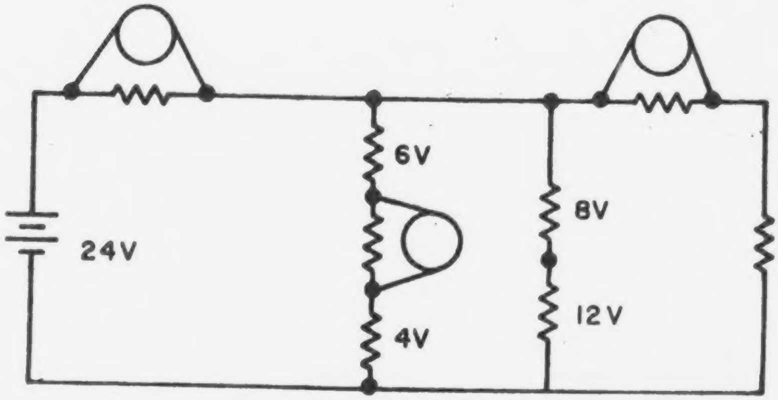
1.


6V
10V
24V
3V

2.



3.


6V
24V
8V
10V
12V
4V

Have the instructor check your answers.

Instructor's Initials ____________

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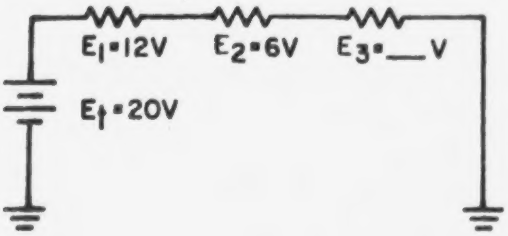
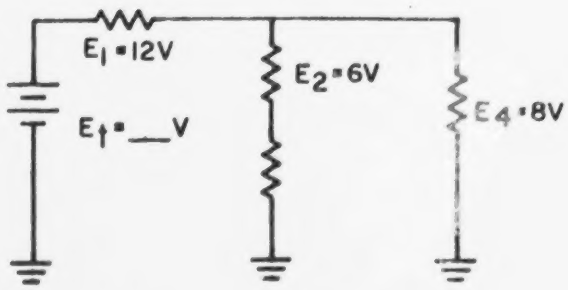
Frame 8

Using Kirchhoff's voltage law, analyze the circuits below to determine the unknown voltage in each circuit. Put your answers on the appropriate blank.

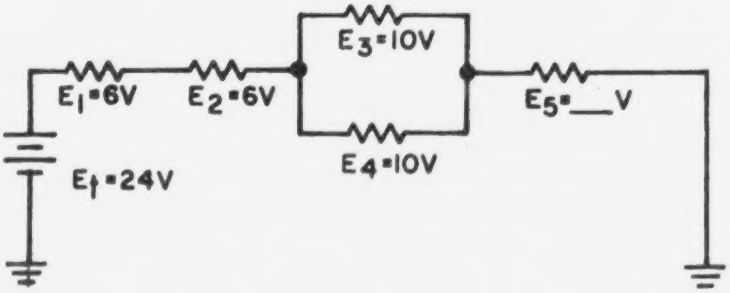
1.


E1=12V
E2=6V
E3=__V
Et=20V

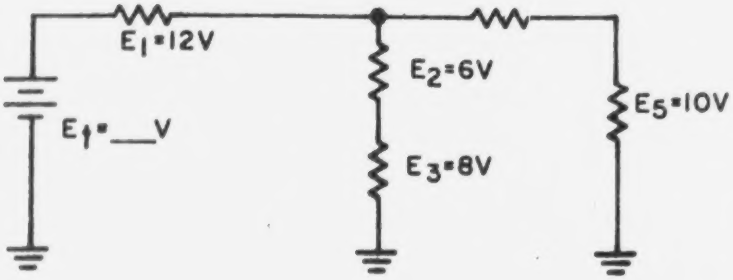
2.


E1=12V
E2=6V
E4=8V
Et=__V

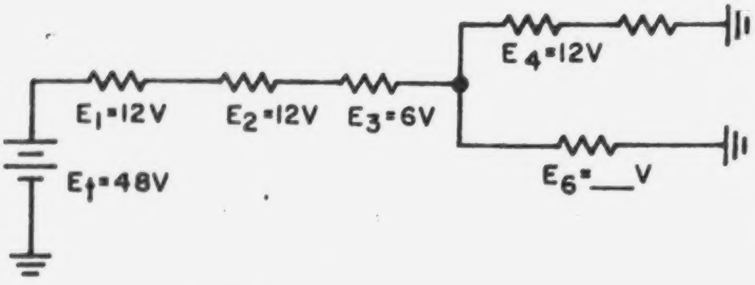
3.


E3=10V
E1=6V
E2=6V
E5=__V
E4=10V
Et=24V

4.


E1=12V
E2=6V
E5=10V
Et=__V
E3=8V

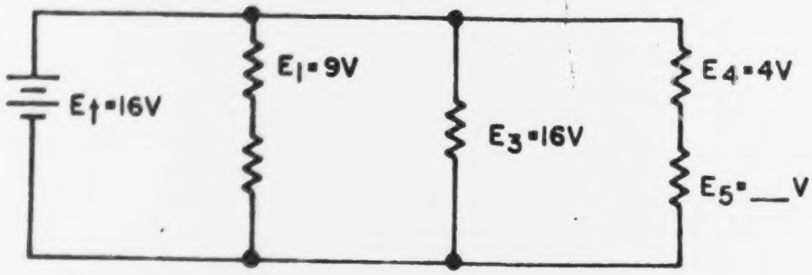
5.


E4=12V
E1=12V
E2=12V
E3=6V
Et=48V
E6=__V

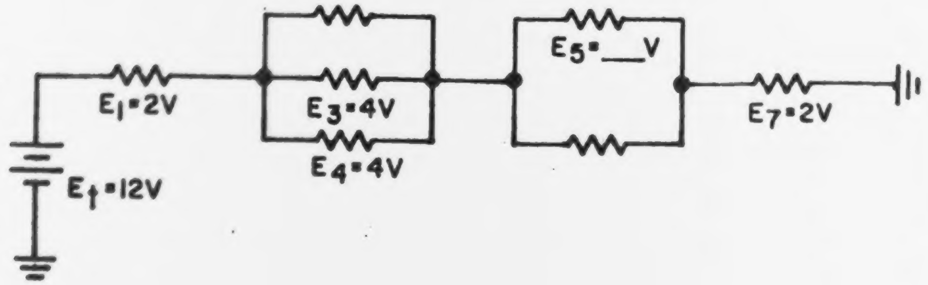
GO TO THE NEXT PAGE.

Frame 8 (Continued)

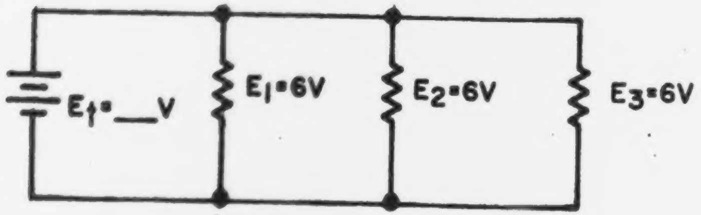
6.


E_t = 16V
E_1 = 9V
E_3 = 16V
E_4 = 4V
E_5 = __ V

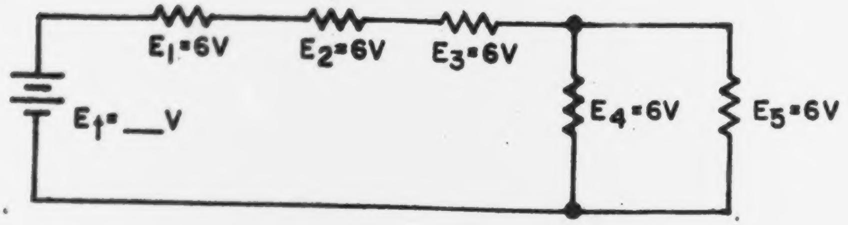
7.


E_1 = 2V
E_3 = 4V
E_4 = 4V
E_5 = __ V
E_7 = 2V
E_t = 12V

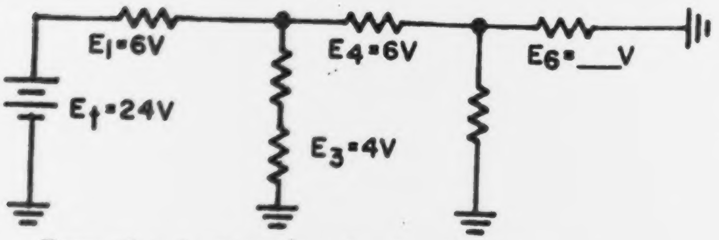
8.


E_t = __ V
E_1 = 6V
E_2 = 6V
E_3 = 6V

9.


E_1 = 6V
E_2 = 6V
E_3 = 6V
E_t = __ V
E_4 = 6V
E_5 = 6V

10.


E_1 = 6V
E_4 = 6V
E_6 = __ V
E_t = 24V
E_3 = 4V

Have the instructor check your answers.

Instructor's Initials ______________

Environmental Pneudraulic Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-WB-303A
20 March 1984

SAFETYING METHODS, PROCEDURES, AND DEVICES

OBJECTIVE

Using mechanical safetying devices, trainer, workbook, and applicable handtools, safety bolts, clamps, and connectors to TO specifications.

EQUIPMENT

Safety wire trainer (2301 Environmental)
(4183 Pneudraulic)
Applicable handtools
Safety wire
Cotter pins
Goggles
TO 1-1A-8

PROCEDURE

There are several methods used to safety aircraft hardware. We wish we could familiarize you with all of them. Since we don't have that much time, we will concentrate on the safetying methods most common to your job.

Follow each part of this workbook closely. Perform each step carefully. Be particularly careful with the sharp ends that are created when safety wire and/or cotter pins are cut.

You will need certain handtools to accomplish the tasks listed in this workbook. Ask the instructor where you may obtain these tools.

Side cutters (diagonal cutters)
Pliers (duckbill or suitable substitute)

Section 1. METHODS OF SAFETYING

I. Securing with Cotter Pins.

A. Cotter pins are used to secure such items as bolts, screws, pins, castellated nuts, and shafts.

B. The use of cotter pins is favorable because they can be installed and removed quickly.

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DISTRIBUTION: X
3370 TCHTG/TTGU-P - 250; DAV - 1
Designed for ATC Course Use. Do Not Use on the Job.

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II. Securing with Safety Wire.

A. Single Wire Method.

1. This method is used to safety closely spaced fillister head screws (screws with holes drilled through the head) in a closed geometrical pattern.

2. The wire is installed so that the screws cannot loosen.

3. Always use the largest size wire that the hole will accommodate.

B. Double Twist Method.

1. This is the most common method of safety wiring used.

2. The double twist method can be used to safety bolts, nuts, and screws.

a. If parts are closely grouped, it is more convenient to safety wire them to each other. This is called series.

b. The maximum number of widely spaced bolts that can be wired in a series is three.

c. The maximum length of wire that can be used is 24 inches.

d. Bolts, nuts, and screws which are spaced more than 6 inches apart shall not be wired in series, but safetied individually.

Section 2. SAFETYING PROCEDURES

I. Using Cotter Pins.

A. In the lower left corner of the safety wire trainer is a castle nut for you to secure.

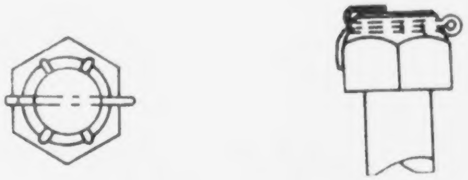

Figure 1. Cotter Pin Installation.

B. Refer to figure 1 for correct installation of the pin and perform the following steps. Use Section 16 of TO 1-1A-8 for additional information.

1. If the castle nut is loose ask the instructor for a wrench to tighten it. Align the nut so that a cotter pin will pass through it and the hole in the bolt.

2. Select the largest size cotter pin that the hole will accommodate.

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3. Push the cotter pin through the hole in the bolt as far as it will go. The long side of the cotter pin should be up.

4. With the side cutters, bend the long side of the cotter pin straight up. Cut it off so that it resembles the pin shown in figure 1. CAUTION: Hold your free hand over the nut while cutting the pin so that the snipped end won't fly up and strike you in the eye.

5. Bend the cut side of the cotter pin over the bolt head and tap it flat with the side cutters.

6. Bend the other side of the cotter pin straight down. Cut it off so that it looks like the pin in figure 1. Tap with the side cutters until it lies flat against the nut.

7. When you feel that you have properly safetied the castle nut, notify your instructor.

II. Using Safety Wire.

A. Single Wire Method.

1. On the right side of the safety wire trainer there is an electrical connector. The base of the connector is fastened to the trainer board by four fillister head screws.

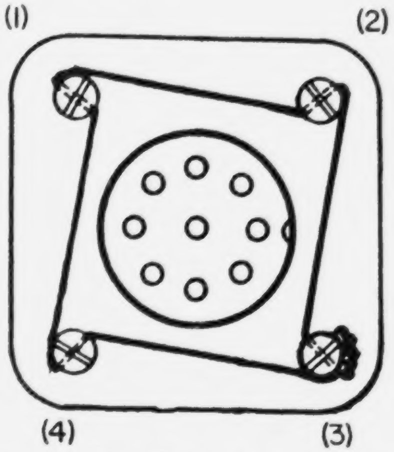

Figure 2. Top View of Connector Plug.

2. Refer to figure 2 for correct installation of the wire and perform the following steps.

a. Cut a piece of safety wire approximately 12 inches long.

b. Thread the wire through the hole in the head of screw number 1 until the ends are about equal in length.

Note: If the hole in the screw is blocked by the body of the connector, the screw may be loosened enough to get the wire through. After the wire has been threaded through the hole, retighten the screw before taking the wire to the next screw.

c. The wire should be threaded through screws 2 and 4 so that if screw number 1 tries to loosen, force will be applied in the tightening direction to these adjoining screws. The same procedure must be used on all four screws.

d. After you have threaded the wire through the hole in screw number 3, use the pliers and twist the ends of the wire together starting at the hole.

e. Cut the wire so that a pigtail about 1/4 to 1/2 inch long remains. Note: The pigtail should contain a minimum of 4 to 6 twists.

f. Bend the pigtail around the screw so that it looks like the wire in figure 2. This will help keep someone from snagging their hand on the safety wire.

g. When you feel that you have properly safetied the four fillister head screws, notify your instructor.

B. Double Twist Method.

1. Across the top of the safety wire trainer there are four bolt heads in a straight line.

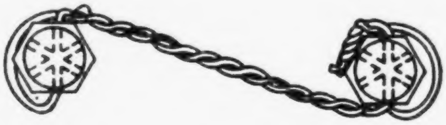

Figure 3. Bolt Heads Safetied by the Double Twist Method.

2. Refer to figure 3 for correct installation of the wire. Safety the first two bolt heads from the left by performing the following steps.

a. If the bolts are loose, ask the instructor for a wrench to tighten them.

b. Cut a piece of safety wire approximately 12 inches long.

c. Thread the wire through the hole in the bolt head until the ends are about equal in length.

d. The wire may be twisted by hand except for the final few twists which should be made with pliers to properly secure the wire ends.

e. The wire must be twisted so that the loop around the bolt head stays down. Extreme care should be taken when twisting the wire to insure that it is tight but not stressed to the point where breakage might occur under a slight load or vibration.

f. Thread the wire through the second bolt head so that if either bolt head tries to loosen (turn counterclockwise), force will be applied in the tightening direction to the other.

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g. Use the pliers to twist the wire counterclockwise.

h. Cut the wire so that a pigtail about 1/4 to 1/2 inch long remains. Note: The pigtail must contain a minimum of 4 to 6 twists.

i. Bend the pigtail around the bolt head so that it looks similar to that in figure 3.

j. If you feel that you have properly safetied the two bolt heads, notify your instructor.

C. Safety Wiring V-Band Clamps.

1. On the safety wire trainer there is a piece of ducting connected by a V-band clamp.

2. Refer to Section 18 of TO 1-1A-8 for correct method of safetying the V-band clamp.

3. When you have completed this project, notify your instructor.

D. Safety Wiring Three Bolts in a Row.

1. Refer to Section 16 of TO 1-1A-8 for proper procedures of safety wiring three bolts in a row.

2. When you have completed this project, notify your instructor.

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Environmental/Pneudraulic Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-WB-303
26 October 1983

TORQUE WRENCH PERFORMANCE

OBJECTIVE

Using a trainer and applicable tools, torque aircraft type nuts according to specified values.

EQUIPMENT

Torque wrench
Hinge handle
9/16" Socket wrench
Torque Wrench Application Trainer

PROCEDURES

1. Locate the Torque Wrench Application Trainer.

2. Get a torque wrench, hinge handle, and a 9/16" socket wrench from Tool Locker #3.

3. Hold the torque wrench in your hand so that you can see the graduations on the grip and shaft. Compare the torque wrench to Figure 1 below and familiarize yourself with its parts. (Note: On some torque wrenches the locking device is located at the bottom of the grip.) Look at the shaft scale. It is graduated in increments of 50, from 100 to 750 inch pounds. Look at the vernier scale. It is graduated in increments of 5, from 0 to 50 inch pounds. By turning the grip and

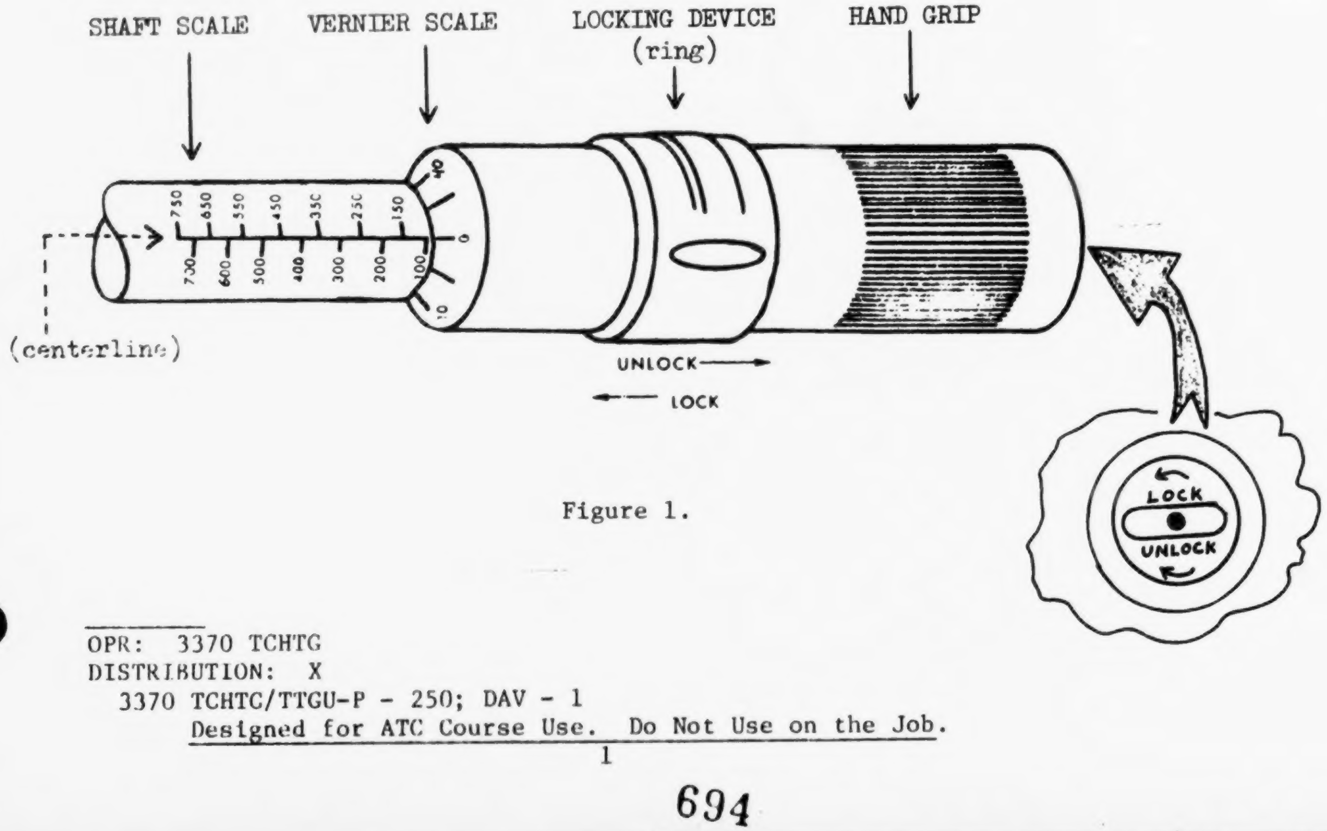
SHAFT SCALE
VERNIER SCALE
LOCKING DEVICE
(ring)
HAND GRIP
750
650
550
450
350
250
150
750
600
500
400
300
200
100
40
0
10
(centerline)
UNLOCK
LOCK
LOCK
UNLOCK

Figure 1.

OPR: 3370 TCHTG
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Designed for ATC Course Use. Do Not Use on the Job.

aligning one of the vernier scale markings with the centerline, you can get any torque setting you want from 100 to 750 inch pounds, to the nearest 5 inch pounds.

4. Unlock the torque wrench hand grip either by sliding a locking ring to the rear or turning a locking device in the direction of the arrow shown on the defice. Ask the instructor for assistance if needed.

5. Set the torque wrench at 200 inch pounds by turning the hand grip clockwise until the '0' on the vernier scale is aligned with the '200' on the shaft scale centerline.

6. "Lock in" the torque wrench either by sliding a locking ring forward or turning a locking device. (NOTE: The hand grip will NOT lock if the vernier scale mark and shaft scale centerline are not exactly aligned with each other.)

7. Attach the 9/16" socket wrench to the square drive on the end of the torque wrench.

8. Finger tighten all six (6) stud bolt and nut assemblies on the trainer until they are just barely snug - NOT tight.

9. Before doing step 'a' below, read steps a, b, and c.

a. Call the instructor and he/she will go through this procedure with you, both of you holding the torque wrench.

b. Place the socket of the torque wrench on nut 1.

c. Holding the torque wrench as shown in Figure 2 below, and using a very slow, very steady, smooth pull, pull the handle toward you until the wrench "breaks away." (It will feel as though the wrench has slightly slipped.) Do NOT pull beyond this point because the nut is now torqued to exactly 200 inch pounds.

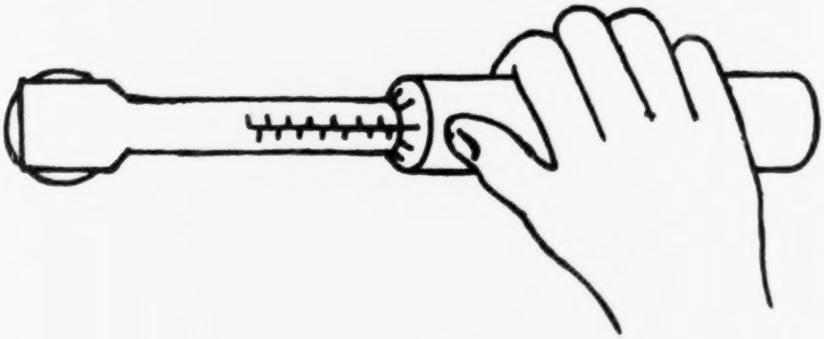

Figure 2.

d. Remove the socket and wrench from the nut that you have just torqued.

10. Reset the torque wrench to a value of 175 inch pounds (150 on the shaft scale plus 25 on the vernier scale). Torque nut 2 to 175 inch pounds.

____________Instructor Initials

11. Torque the four (4) remaining bolts to the following values:

3 - 120 inch pounds
4 - 235 inch pounds
5 - 190 inch pounds
6 - 210 inch pounds

12. Loosen all six (6) nuts using the hinge handle and 9/16" socket wrench.

13. Now you should know how to use a torque wrench. If you don't, notify the instructor that you wish to repeat the procedures in this workbook. When you are ready, ask the instructor for the Progress Check.

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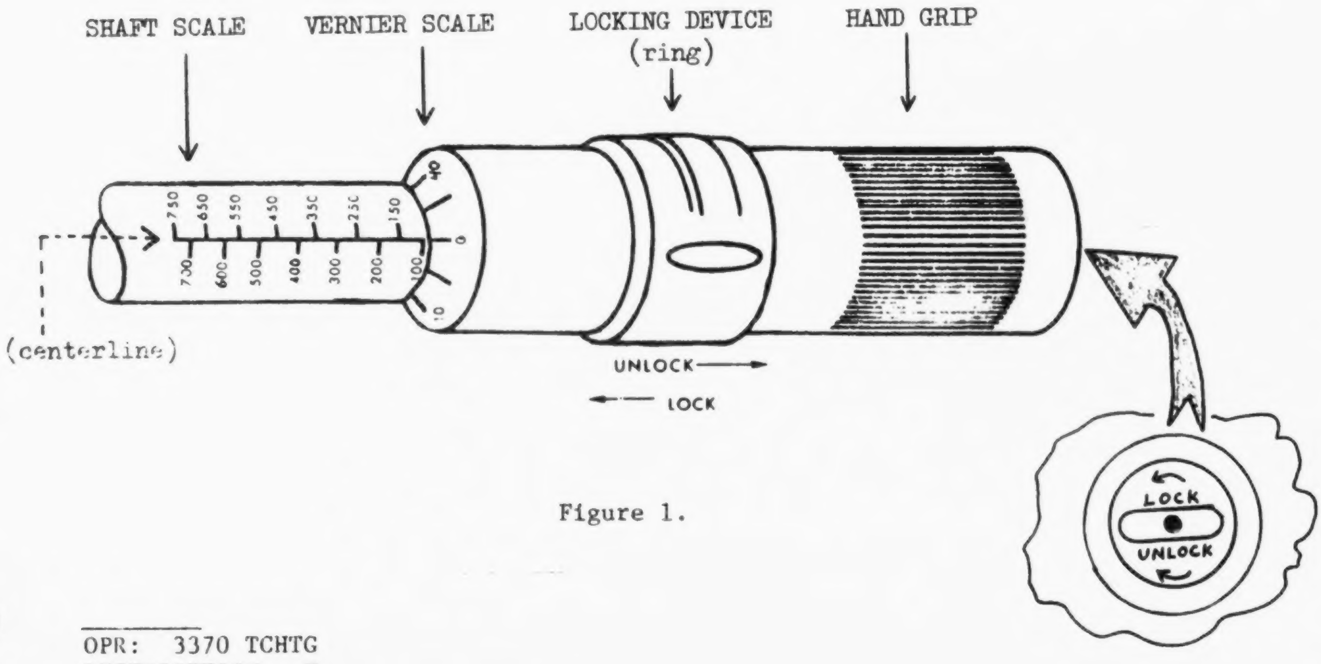
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VERNIER SCALE
LOCKING DEVICE (ring)
HAND GRIP
750
650
550
450
350
250
150
700
600
500
400
300
200
100
40
0
10
(centerline)
UNLOCK
LOCK
LOCK
UNLOCK

Figure 1.

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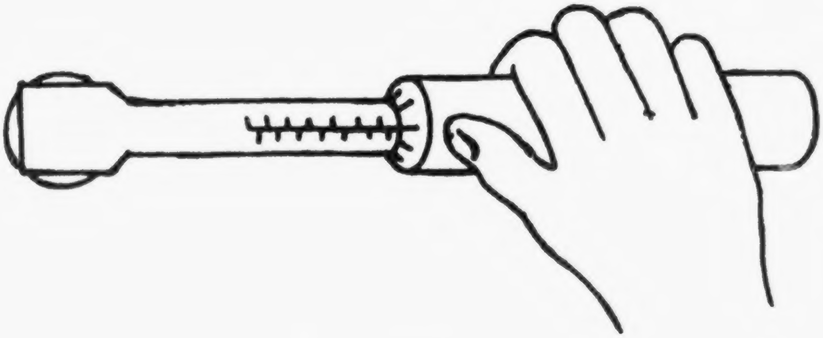

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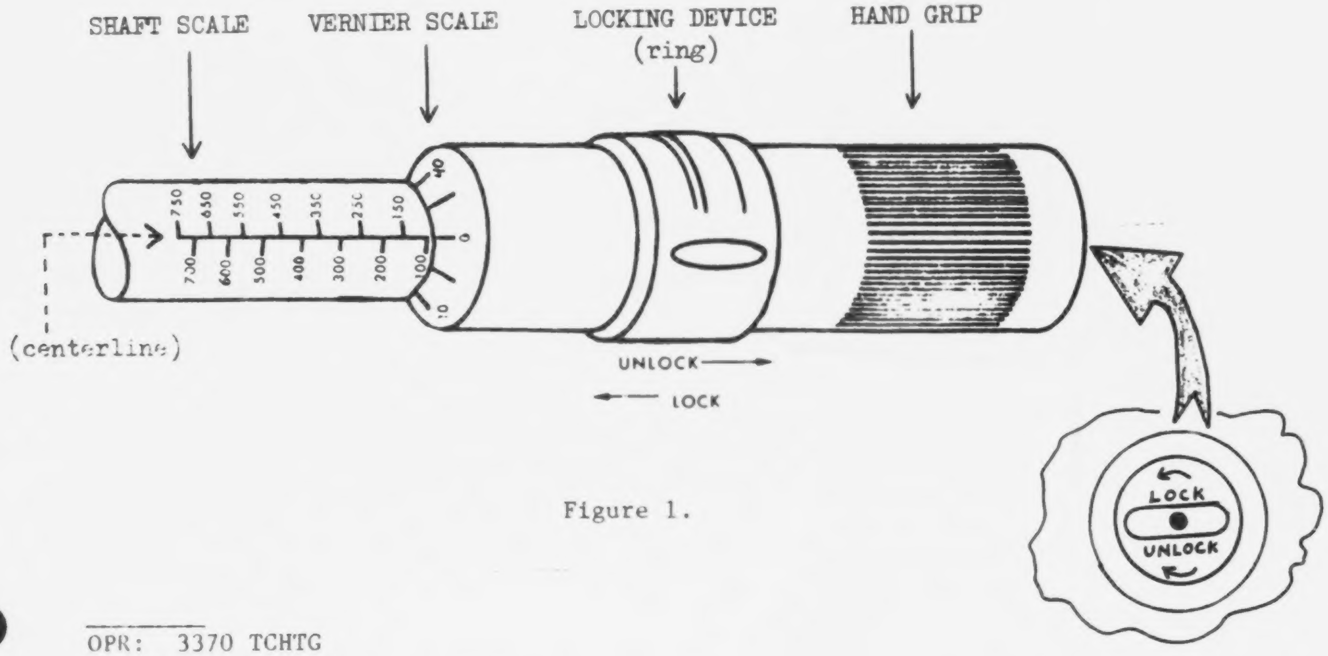
SHAFT SCALE
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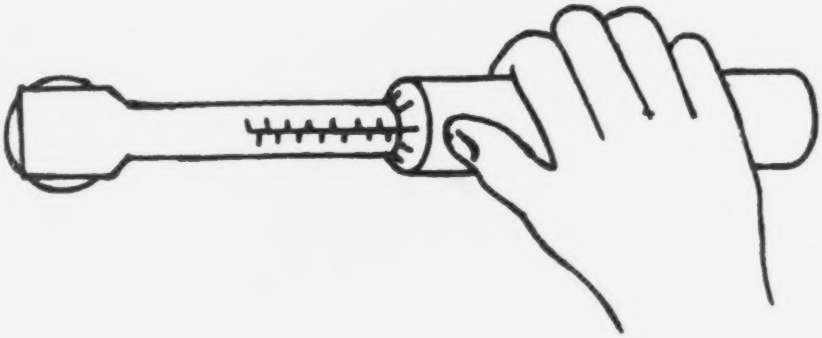

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Cindy

PROGRAMMED TEXT

3ABR42331-PT-303B

Technical Training

Aircraft Environmental System Mechanic

USE OF GENERAL PURPOSE CONNECTORS, BONDING, SHIELDING, AND GROUNDING

27 February 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: 9.7

OBJECTIVES

Identify the terms associated with aircraft electrical wiring to 80% accuracy.

INSTRUCTIONS

This programmed text presents information in small steps called "Frames." After each frame you are asked to respond to the information in some way. Read the material and make your response. Compare your answers with the correct answers given at the top of the next page. If you find you are incorrect, reread the frame to get the correct information. If you are right, and you understand the information presented in that frame, proceed to the next. This is satisfactory, however, do not skip ahead unless the text directs you to do so.

Supersedes 3ABR42331-PT-303B, 11 August 1977.
OPR: 3370 TCHTG
DISTRIBUTION: X
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Aircraft electrical wiring is constructed of tin-coated copper or aluminum wire. Normally it is insulated, shielded, bonded and grounded (if needed) to the aircraft when installed. During inspection or repairs, make sure that insulation and shielding are not damaged.

Answer the following question by circling the correct answer.

1. Before installing an electrical wire from a shutoff valve to a circuit breaker, what would have to be done to the wire?

   a. Insulated
   b. Shielded
   c. Bonded
   d. Grounded (if needed)
   e. All of the above

Answer to Frame 1: 1. e

Frame 2

Shielded cable must be properly bonded and secured. In each cable, many small strands of wire are used to form a single conductor. These stranded cables are preferred rather than a single heavy wire in order to make the finished cable more flexible. The individual strands are twisted together and then covered with a suitable insulating material. Where excessive vibration takes place, flexible stranded cable can cause trouble when not properly secured.

Answer the following question by circling the correct answer.

1. Given a choice between a stranded cable and a single heavy wire, why do maintenance people choose the stranded cable?

   a. Stronger
   b. Lighter
   c. Smaller
   d. More flexible

Answer to Frame 2: 1. d

Frame 3

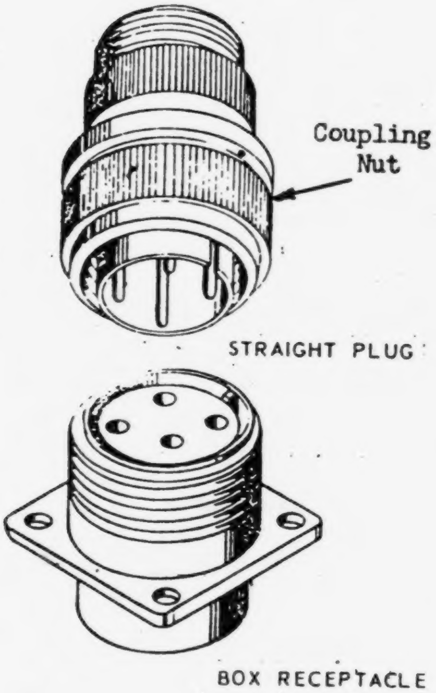

Figure 1. Common Connector.

Detachable connectors (cannon plugs) are used to join segments of electrical circuits installed in aircraft. These connectors must hold electrical circuits securely without undue voltage drop, under extreme vibration, rapid temperature changes, and vast altitude differences. A common connector consists of a plug assembly (see figure 1 for example) and a receptacle assembly that are fastened together by a coupling nut. You must be careful not to cross-thread, strip, or jam the nut.

Answer the following question by circling the correct answer.

1. What is the purpose of a cannon plug?

   a. Connect insulation
   b. Ground electrical circuits
   c. Join segments of electrical circuits
   d. Bond electrical circuits to aircraft structure

Answer to Frame 3: 1. c

Frame 4

We have covered some points in this book that are important for you to remember. Therefore, we will quickly cover them again.

- Normally, aircraft wiring is insulated, shielded, bonded and grounded (if needed) to the aircraft when installed.
- Stranded cables are preferred rather than a single heavy wire in order to make the finished cable more flexible.
- Detachable connectors are used to join segments of electrical circuits installed in aircraft.
- You must be careful not to cross-thread, strip, or jam the coupling nut on a connector plug.

Frame 5

Shielding - Preventing one component from affecting another through their common electric or magnetic field.

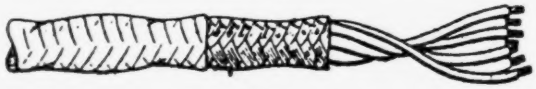

Figure 2. Shielded Multiconductor Cable.

Shielded cable (figure 2) has a metallic braid over the insulation to provide a barrier against electrostatic interference. To obtain satisfactory results from shielded cable, the shield must be unbroken and must extend to a point as near the end of the conductor as practicable.

Answer the following question by circling the correct answer.

1. What does a shielded cable (located inside a pressure regulator) protect against?

   a. Heat
   b. Water
   c. Shorting
   d. Electrostatic interference

Answer to Frame 5: 1. d

Frame 6

Grounding - The electrical connecting of wiring to a primary structure (the main frame, fuselage, and wing structury of the aircraft) for the return of current.

In the wiring of practical circuits, one side of the voltage source is usually grounded. For the 120VAC power line in residential wiring, the ground is actually earth ground, usually made by connecting a wire to a metal coldwater pipe. For aircraft equipment, the ground is connected to a metal chassis (see figure 3), which is used as a common return for connections to the voltage source.

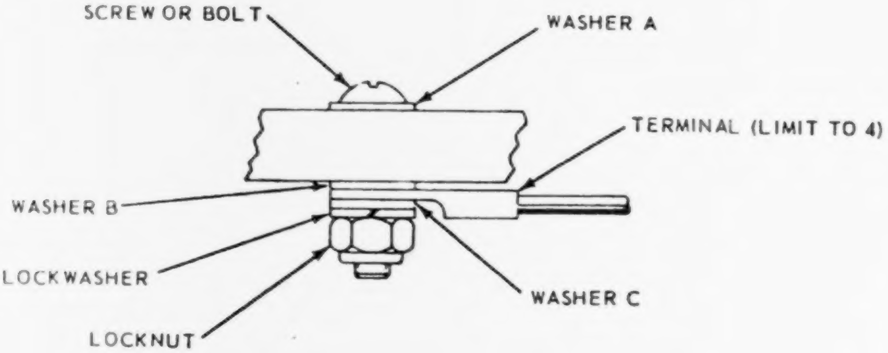

Figure 3. Grounding to Flat Surface.

Answer the following question by circling the correct answer.

1. If you need to check a component for 28VDC power, where would you ground the negative lead of thy multimeter?

   a. Earth
   b. Aircraft structure
   c. Metal cold water pipe
   d. To the control switch

Answer to Frame 6: 1. b

Frame 7

Bonding - The electrical connecting of two or more wires not otherwise adequately connected.

Bonding is used to connect wires (usually in bundles) to the aircraft structure for purposes other than grounding. The wiring used on aircraft can be many feet long. Therefore, it must be bonded in several places to prevent the wiring from breaking due to excess vibration. Bonding also keeps wiring from getting in the way of other equipment.

Answer the following question by circling the correct answer.

1. Why would your shop supervisor insist that you bond all the wiring bundles that you work on?

   a. Helps insulation
   b. Stops magnetic fields
   c. Protects pilot from electric shock
   d. Prevents wiring from breaking due to vibration

Answer to Frame 7: 1. d

Frame 8

In this book we have covered several items that are important for you to remember. Therefore, we will review them briefly.

1. Shielded cable provides a barrier against electrostatic interference.
2. Aircraft wiring is grounded to the aircraft structure.
3. Long wire bundles must be bonded to prevent the wiring from breaking due to excess vibration.
4. Detachable connectors are used to join segments of electrical circuits without undue voltage drops. The most common type of such a connector is called a cannon plug.

Frame 9

Wiring maintenance is an important part of environmental systems. In some cases one wire can prevent an aircraft from flying. That is why it is important for you to retain your basic wiring maintenance knowledge.

WORKBOOK

3ABR42331-WB-303B

Technical Training

Aircraft Environmental System Mechanic

WIRING MAINTENANCE

14 October 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

Environmental/Pneudraulic Branch
Chanute AFB, Illinois

WIRING MAINTENANCE

OBJECTIVES

Using a trainer, applicable tools and equipment, solder wire to connectors and install electrical wiring IAW TO 1-1A-14.

INSTRUCTIONS

Tell the instructor that you are ready to view the two films titled "Stripping and Crimping" and "Soldering and Soldering Iron Preparation." After viewing the films, start with the instructions in this workbook.

EQUIPMENT

5/6 Nut Driver
Terminal Lugs
Wire Splice Connections
Crimping Tool
Size 20 Wire (3 pieces)
Wire Stripper
Diagonal Cutting Pliers
TO 1-1A-14
Soldering Iron
Soldering Iron Stand
Rosin Core Solder
Flux
Wire Maintenance Trainer
Double-Cut Mill File

PROCEDURE

Note: Read the item through, completely, before performing each step.

1. Stripping Electrical Wiring

a. Before an electrical wire can be soldered, it must have some of the insulation removed. Removing part of the insulation from the wire is called stripping.

b. Stripping electrical wires is done with a wire stripper. The type of stripper that you will use is a plier-type hand stripper.

Supersedes 3ABR42331-WB-303B, 23 February 1981, which may be used until existing stocks are exhausted.
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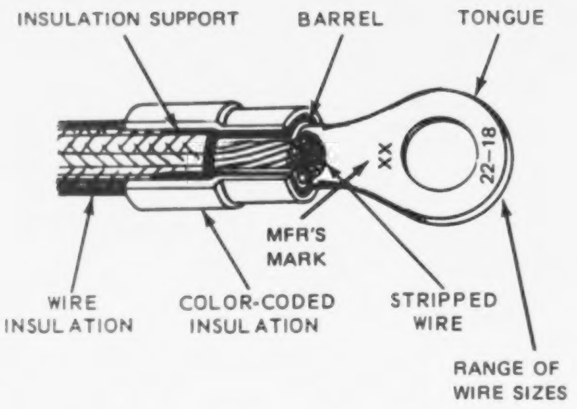

INSULATION SUPPORT
BARREL
TONGUE
XX
22–18
MFR'S MARK
WIRE INSULATION
COLOR-CODED INSULATION
STRIPPED WIRE
RANGE OF WIRE SIZES

Figure 1. Preinsulated Terminal Lug - Cut-Away.

c. In TO 1-1A-14, read paragraph 2-44. This paragraph gives the steps for stripping electrical wires. As you read this paragraph, look at figure 2-21 which is on the following page in the TO.

d. Follow the steps in TO 1-1A-14 to strip each end of a 6-inch (15cm) piece of wire 3/16 of an inch (.476cm). When you feel that the wire is stripped, as shown in the TO, have the instructor check it.

Note: If part of the insulation still remains on the wire, trim it off with your diagonal pliers.

2. Application and Use of the Crimping Tool and Wiring Connectors.

a. The crimping tool, figure 2, is used for connecting (crimping) preinsulated terminals (terminals with plastic covered barrels), in figure 1, and splicing connectors to electrical wiring.

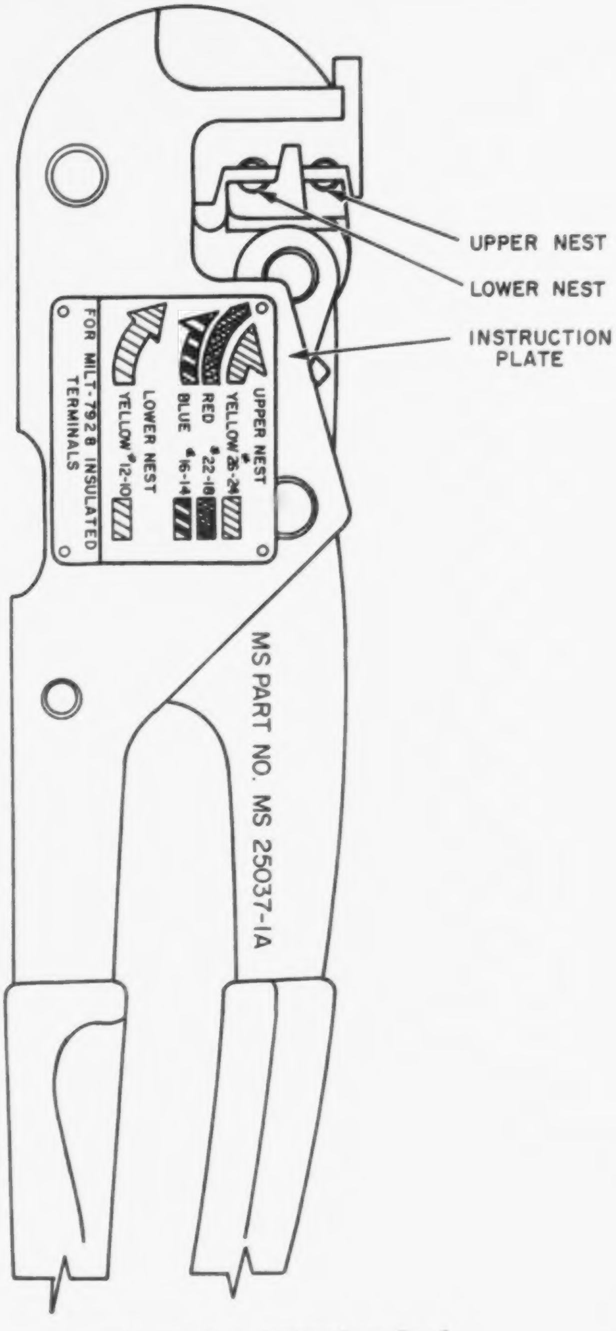

UPPER NEST
LOWER NEST
INSTRUCTION PLATE
UPPER NEST
YELLOW #26-24
RED #22-18
BLUE #16-14
LOWER NEST
YELLOW #12-10
FOR MILT-7928 INSULATED TERMINALS
MS PART NO. MS 25037-1A

Figure 2. Crimping Tool.

Answer the statements as true (T) or false (F).

1. _____ Preinsulated terminals can be crimped with any type of crimping tool.

b. Insulated terminals and connectors are color coded for the size of electrical wiring with which they are to be used. The color coding is done by making the insulation of each size of terminal or connector a different color. The instruction plate on the crimping tool, figure 2, shows the nest (jaw section) that is to be used for the size of the wire and color of the terminal or connector.

Answer the statements as true (T) or false (F).

1. _____ The instruction plate of the crimping tool shows the jaw section to be used by code.

2. _____ Color coded connectors show the wire size that may be used.

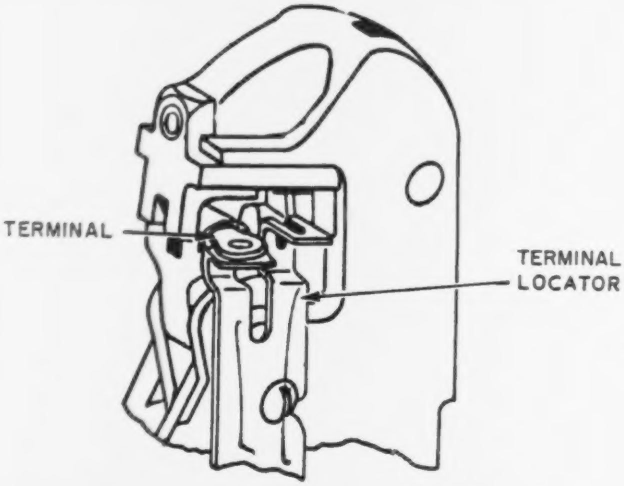


Figure 3. (Shown in the up position).

c. Figure 3 shows the side of the crimping tool opposite the instruction plate side. On this side of the crimping tool is a terminal locator. This locator is used only when crimping a terminal lug. The locator acts as a stop for the lug. The locator can be turned out of the way. This is done when wire splice connections need to be crimped. The terminal is moved in the correct nest until the terminal barrel is against the locator.

Answer the statements as true (T) or false (F).

1. _____ The locator on the crimping tool is used when crimping terminal lugs.

2. _____ The locator is on the same side of the crimping tool as the instruction plate.

d. This crimping tool has self-locking steps (rachets). Once you start to close the handles, they will have to be closed all the way before the crimping tool will open again. The purpose of the self-locking rachet is to give a means for locking connectors in the crimper. The wire can then be put in the barrel of the terminal lug or splice connection.

Answer the statements as true (T) or false (F).

1. _____ The crimping tool has a self-locking rachet.

2. _____ The crimping tool may be opened no matter how far the handles have been closed.

Note: Another type of crimper has only one nest. The one nest can take all sizes of wire from number 10 through number 26. This type of crimping tool has a wire size selector knob. Other than this the two tools work the same.

e. Get a crimping tool. Operate it a few times without any connectors. Squeeze the handles slowly. Listen for a click at each step of the self-locking ratchet. Also, notice that the opening at the jaws gets smaller at each step of the self-locking ratchet.

3. Crimping Terminal Lug Connections

a. Open TO 1-1A-14 to page 5-9, read paragraph 5-14.

b. Take another piece of wire 6 inches (15cm) long and strip one end so that 3/16 of an inch (.476cm) of the wire is showing.

c. Twist the strands of wire so they can be put in the terminal lug barrel.

d. Select a terminal lug. Put it, TONGUE first in the proper nest of the crimping tool. This is shown by the color code on the tool data plate. The barrel of the terminal lug should be up against the locator stop of the crimping tool, figure 3.

e. Slowly squeeze the crimping tool handles until the terminal lug is held in place.

Caution: Do not squeeze so hard as to dent the terminal lug barrel.

f. Put the stripped end of the wire in the terminal lug barrel. Make sure the insulation of the wire is flush against the barrel of the terminal lug, see figure 4.

g. Squeeze the crimping tool handles closed. When the handles are closed, the ratchet will release.

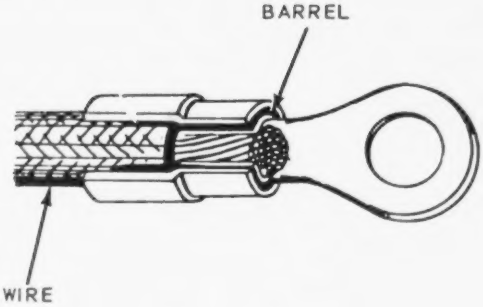


Figure 4.

h. Take the crimped terminal lug from the crimping tool.

i. Repeat steps a thru i with the wire you stripped previously.

j. Have the instructor check your work.

4. Crimping Wire Splice Connections

a. Turn to page 5-30 in TO 1-1A-14 and read paragraph 5-53.

b. Take the wire that you just crimped a lug to, and cut it in half, strip one end of each wire about 3/16 of an inch (.476cm).

c. Twist the strands of wire so they can be put in the barrels of the splice connection.

d. Turn the locator stop down and out of the way, see figure 5.

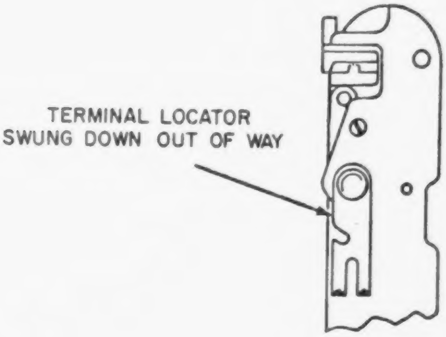


Figure 5.

e e. Select a splice connection. Put it in the crimping tool so that only one side of the splice will be crimped, see figure 6. Be sure that the side of the splice to be crimped is on the conical die side of the locator groove in the upper nest.

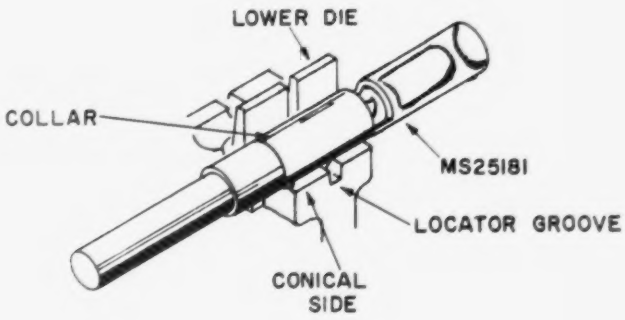


Figure 6.

f. Put the wire in the wire inside of the splice connector until it stops.

Caution: Do not get fingers or any objects caught in the jaws of the crimping tool.

g. Crimp the connection by squeezing the handles of the crimping tool all the way closed.

h. Take the wire splice connection from the crimping tool. Check to make sure the connection is tight.

i. Have the instructor check your work.

j. Take the splice that you just made and turn it around and install it in the crimping tool.

k. Take the other half of the wire with the terminal lug on it and put it in the splice and crimp it down. Have the instructor check your work.

5. Soldering Electrical Connections

a. To know how to make good electrical connections with solder is important, because of the many different conditions to which an aircraft is subjected. The electrical connections must be able to carry electrical current with no loss of current due to leakage or resistance.

b. A detachable electrical AN-connector, figure 7, has a plug (male) and receptacle (female) assembly. The two parts are fastened together by means of a coupling nut. You must take care not to crossthread, strip, or jam the nut. Notice also, that the pin contacts in the AN-connector have cups in which a wire can be place and soldered.

c. In TO 1-1A-14, Section IX, page 9-1, read paragraph 9-7 that defines soldering.

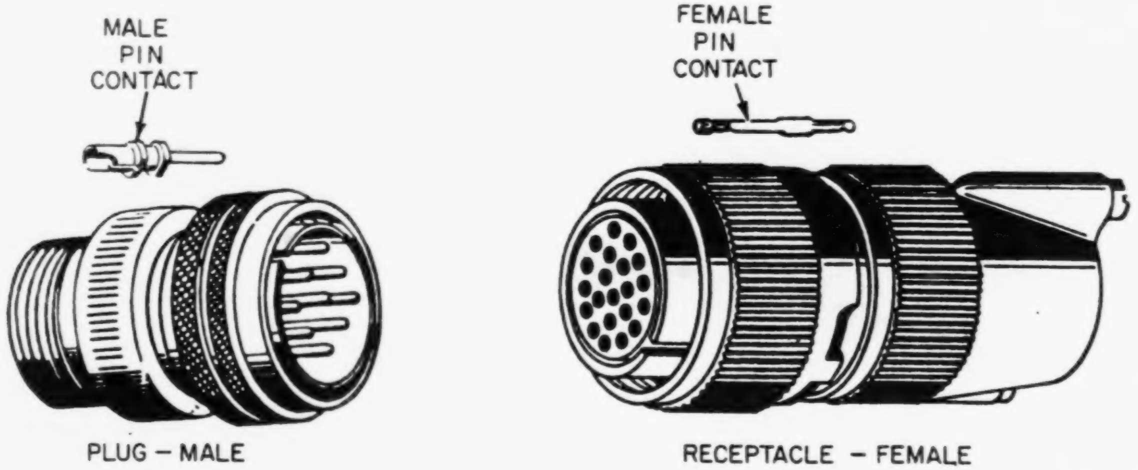


Figure 7. AN-Connector.

d. Solder used for soldering electrical wiring is usually of the 40-60 type. This means that the solder has 40% lead and 60% tin. Solder may be of the core wire or solid wire type. Core wire solder has a core of flux, that may be rosin or acid. Rosin core solder is always used when soldering electrical connections.

Note: Never use acid core solder, for electrical connections. Acid core solder tends to cause corrosion and this will cause a high resistance to the flow of electrical current.

Solid wire solder may be used for soldering electrical connections. When this type of solder is used the rosin flux will have to be put on the wire.

e. Flux is a chemical reducer that is used for conditioning the surfaces to be soldered. When the surface is heated to melt the solder, the flux will melt before the solder. This will help the solder remove any chemical substance that may cuase the solder not to stick to the metal. The rosin flux will also help stop oxidation when the metal is heated.

f. Soldering irons are rated by wattage. The irons can be had in wattages that range from 20 to 500 watts. Soldering irons with wattage ratings of 60, 100, and 200 watts are for general use in soldering electrical wiring.

6. Procedure for Soldering Electrical Connections

a. Tell the instructor that you are ready to use the wire maintenance trainer, see figure 8.

b. Make sure the trainer is UNPLUGGED and the circuit breaker is pulled OUT.

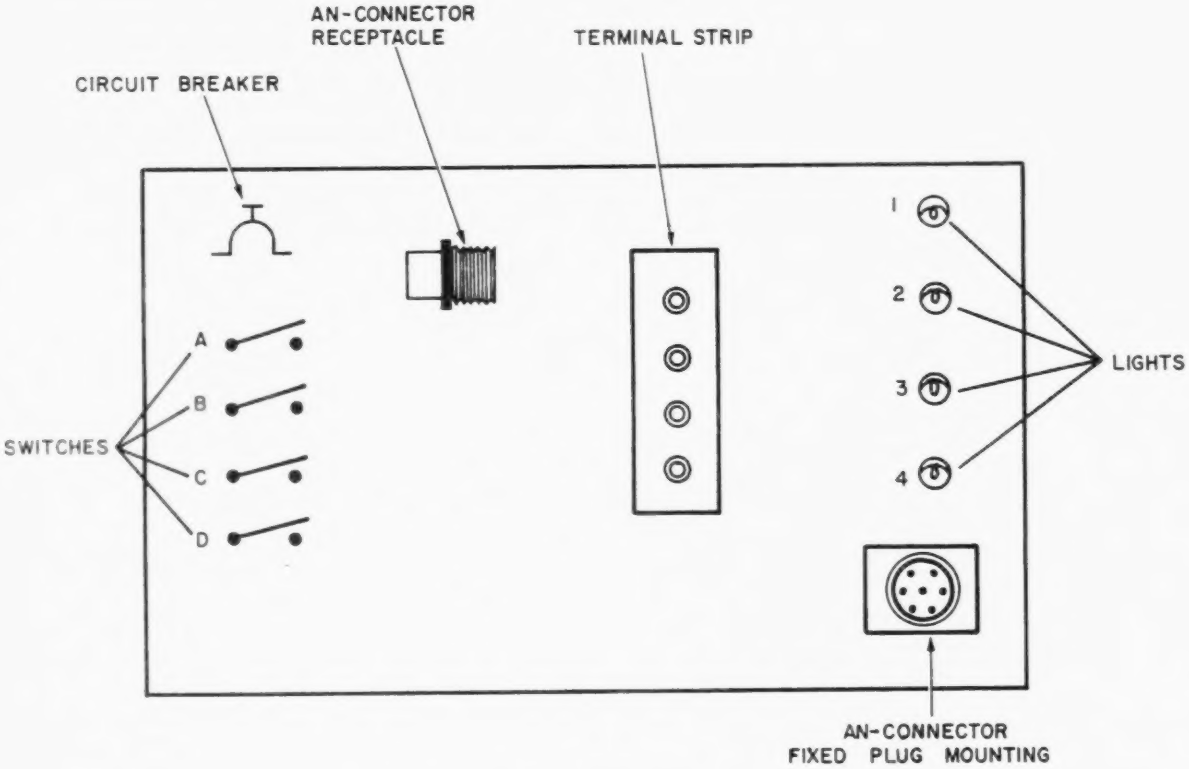

AN-CONNECTOR RECEPTACLE
TERMINAL STRIP
CIRCUIT BREAKER
A
B
C
D
SWITCHES
1
2
3
4
LIGHTS
AN-CONNECTOR FIXED PLUG MOUNTING

Figure 8. Wire Maintenance Trainer.

c. Just below the circuit breaker there are four single pole switches, marked A, B, C and D. Make sure each switch is OPEN.

d. To the right of the switches is an AN-connector. Remove the plug from the AN-connector. Put the plug on the fixed plug mounting.

e. Refer to figure 9 and remove the grommet and back nut from the plug of the AN/connector.

Note: Some AN-connectors may not have a rubber grommet.

f. Take the two wires that you just prepared and set them aside. You will be soldering these wires to the AN-connector plug.

g. Refer to Section 1 of this workbook and strip one end of each wire one-fourth of an inch (0.635cm).

h. Prepare the soldering iron by following the steps in TO 1-1A-14, Section IX, paragraph 9-20.

i. Tin the stripped end of each wire by following the steps in TO 1-1A-14, Section II, paragraph 2-54.

Note: If you need help, ask the instructor.

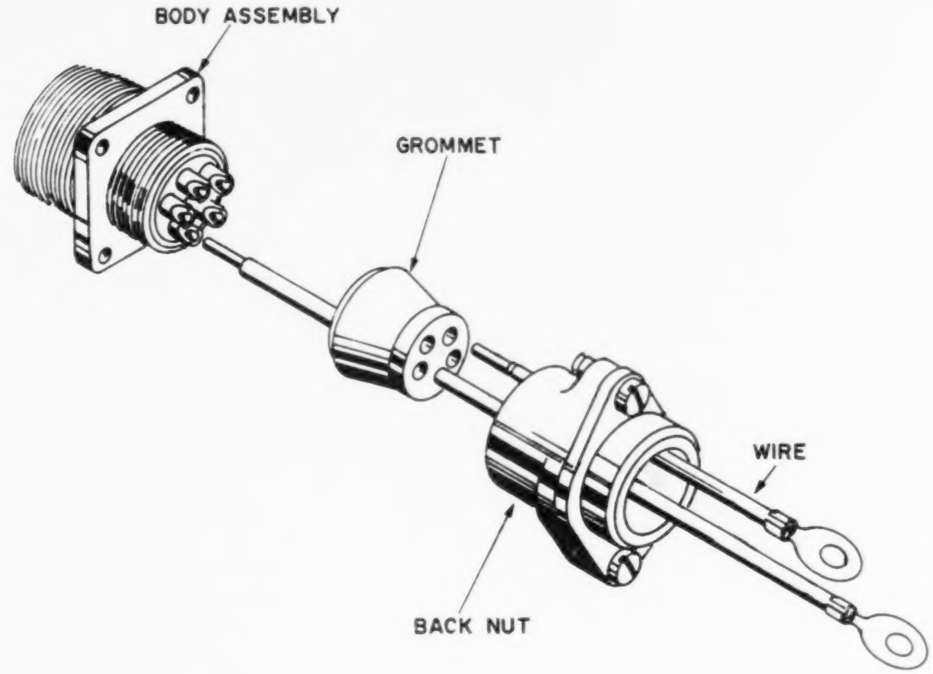


Figure 9.

j. Refer to figure 9 above. Slide the back nut about half way up the wires putting the tinned ends through first. Now push the tinned ends of the wires through the grommet so that the wires will line up with the pins. Push the grommet up the wires to the point where the one wire is spliced.

k. Turn to Section IX of TO 1-1A-14 and read paragraphs 9-32 through 9-40.

l. Solder the tinned ends of the two wires to any two pins of the AN-connector. Follow the steps in paragraphs 9-32 through 9-40 in TO 1-1A-14.

Note: Have the instructor check your work.

m. Disconnect the wires from the AN-connector. You are going to solder the wires into the AN-connector so that switch ______________ will turn on light ____________ and switch ___________ will turn on light _______. Follow the steps of paragraphs 9-32 through 9-40 in TO 1-1A-14.

n. Solder one wire to pin _________ and the other to pin _______ of the AN-connector. After the wires have been soldered to the AN-connector, reassemble the plug, see figure 9. Push the grommet down the wires to the body assembly. Push the back nut over the grommet and screw it onto the body assembly. Now remove it from the fixed plug mounting and connect it to the receptacle, see figure 8.

o. Refer to Section 1 of this workbook and strip the wire end that has no terminal lug. Now refer to Section 3 of this workbook and crimp a terminal lug to this wire. Take the nuts off of terminals ________ and _____________ with the 5/16 nut driver.

p. Connect the wire from pin _________ of the AN-connector to terminal _________ on the terminal strip. Connect the wire from pin _______ of the AN-connector to terminal ___________ on the terminal strip. Tighten the nuts on the terminals so that they are snug.

Note: Have the instructor check your work.

q. Plug the trainer into the 28V DC outlet and push the trainer circuit breaker in.

r. Close the contacts of switch ______, light ________ should illuminate. Close the contacts of switch _______ and light _______ should come on. If the lights do not illuminate, ask the instructor for assistance.

s. Open the contacts of the switches you closed, pull out the trainer circuit breaker and unplug the trainer.

t. Remove the two wires from terminal strip.

u. Take the AN-connector off the AN-receptacle and put it on the fixed mounting, see figure 8. Disassemble the AN-connector and unsolder the wires. Remove the wires from the back nut and grommet and reassemble the AN-connector.

v. Inform the instructor you have completed this project. The instructor will give you further instructions.

SERVICE TEST
PROGRAMMED TEXT
C3ABR42331-PT-303B

Technical Training

Aircraft Environmental Systems Mechanic

USE OF GENERAL PURPOSE ELECTRICAL HARDWARE

14 November 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

OBJECTIVE

Specify general principles relating to the use of general purpose electrical hardware. A minimum of 8 of 10 must be correct.

INSTRUCTIONS

This programmed text presents information in small steps called "Frames." After each frame, you are asked to respond to the information in some way. Read the material and make your response. Compare your answers with the correct answers given at the top of the next page. If you find you are incorrect, reread the frame to get the correct information. If you are right and you understand the information presented in that frame, proceed to the next. This is satisfactory; however, do not skip ahead unless the text directs you to do so.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 250; DAV - 1

INTRODUCTION

The satisfactory performance of present day aircraft depends to a very great extent on the continuing reliability of its electrical system. Improperly or carelessly installed wiring can be a source of both immediate and potential danger, and many malfunctions and failures of the electrical system can be traced to this cause. The performance of the system depends on the quality of the design plus the workmanship used in making the installation. The continued proper performance of the system depends on the "know-how" of the men and women who do the inspection, repair, and maintenance. So show some pride in your work and do the very best job you can at all times. The defense of our country depends on it.

No Response Required

BEST COPY AVAILABLE

Frame 2

Aircraft electrical wiring is constructed of tin-coated copper or aluminum wire. In order to make installation, maintenance, and repair easier, runs of electrical wire and cable in aircraft are broken at specified locations by junctions such as connectors, terminal blocks, busses, etc. Before assembly to these junctions, wires and cables must be cut to length, identified, stripped, and if required, tinned before being soldered.

No Response Required

BEST COPY AVAILABLE

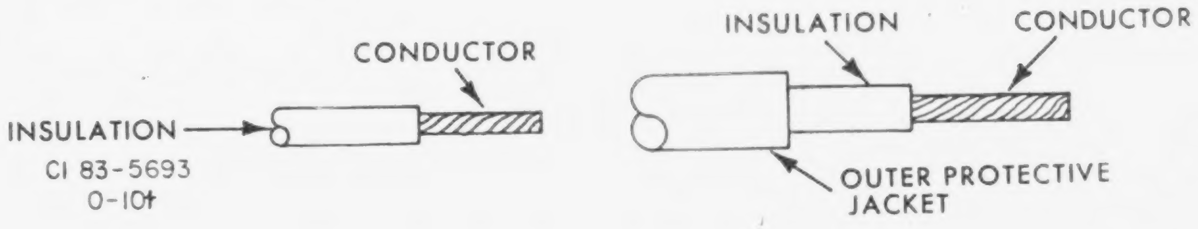

CONDUCTOR
INSULATION
CI 83-5693
0-10†
INSULATION
CONDUCTOR
OUTER PROTECTIVE JACKET

Figure 1. Two Types of Stranded Wires.

Insulated Wire, Figure 1--For the purpose of an electronic installation in an aircraft. An insulated wire consists of a metal conductor covered with a dielectric or insulating material. Wires used in aircraft normally contain stranded conductors for flexibility. Insulation may consist of several materials and layers to provide dielectric insulation, thermal protection, abrasion resistance, moisture resistance, and fluid resistance.

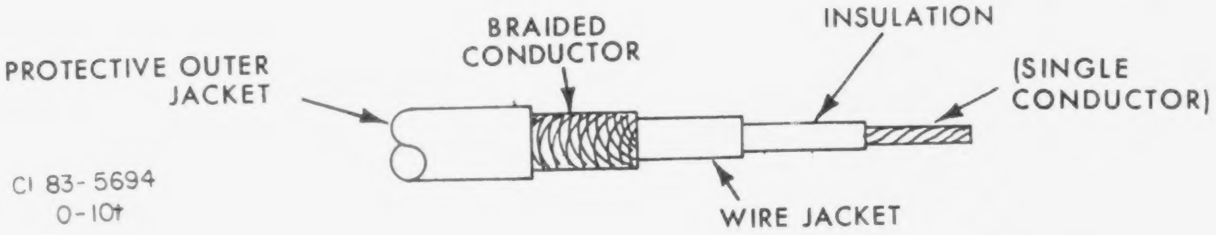

BRAIDED CONDUCTOR
INSULATION
PROTECTIVE OUTER JACKET
(SINGLE CONDUCTOR)
CI 83-5694
0-10†
WIRE JACKET

Figure 2. Coaxial Cable.

Coaxial Cable, Figure 2--A single insulated center conductor with a metallic braided outer conductor. Both center and outer conductors are capable of sending electrical signals.

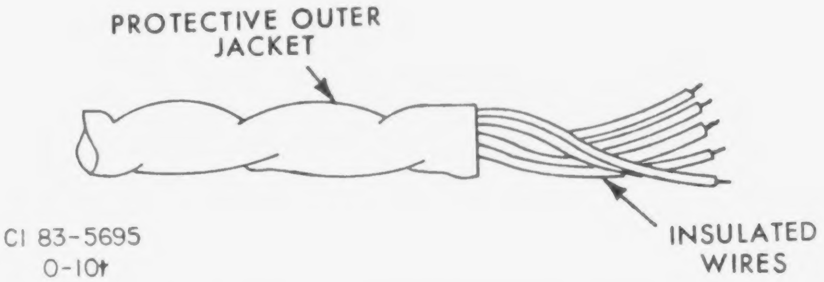

PROTECTIVE OUTER JACKET
CI 83-5695
0-10†
INSULATED WIRES

Figure 3. Multiconductor Cable.

Multiconductor Cable, Figure 3--Two or more insulated conductors contained in a common covering or sometimes twisted together without a common covering.

Frame 3 (Cont'd)

Answer the following questions.

1. Aircraft wiring is usually ____________________ for flexibility.

   a. single conductor
   b. stranded
   c. thick braided
   d. thin coated

2. What type of electrical conducting device has an insulated conductor through which a central, insulated conductor runs with both conductors being able to send electrical signals?

   a. Stranded wire
   b. Insulated wire
   c. Coaxial cable
   d. Multiconductor cable

Answers to Frame 3: 1. b , 2. c

Frame 4

Shielding--Preventing one component from affecting another through their common electric or magnetic field.

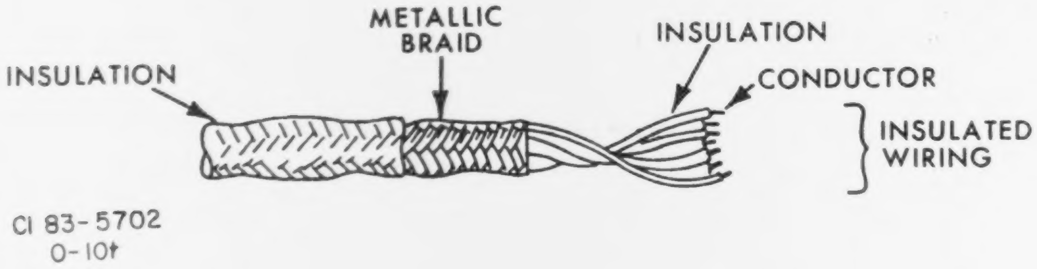


Figure 4. Shielded Multiconductor Cable.

Shielded Cable, Figure 4--Has a metallic braid over the insulation to provide a barrier against electrostatic interference. To obtain satisfactory results from shielded cable, the shield must be unbroken and must extend to a point as near the end of the conductor as practicable. Shielded cable differs from coaxial cable in that it does not use the metallic braid for conducting purposes.

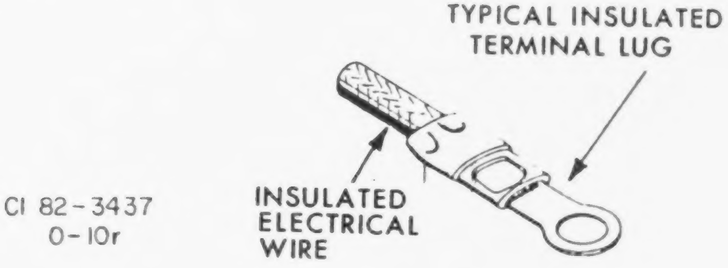
Answer the following questions by circling the correct answer.

1. What does a shielded cable (located around a radar unit) protect against?

   a. Heat
   b. Water
   c. Shorting
   d. Electrostatic interference

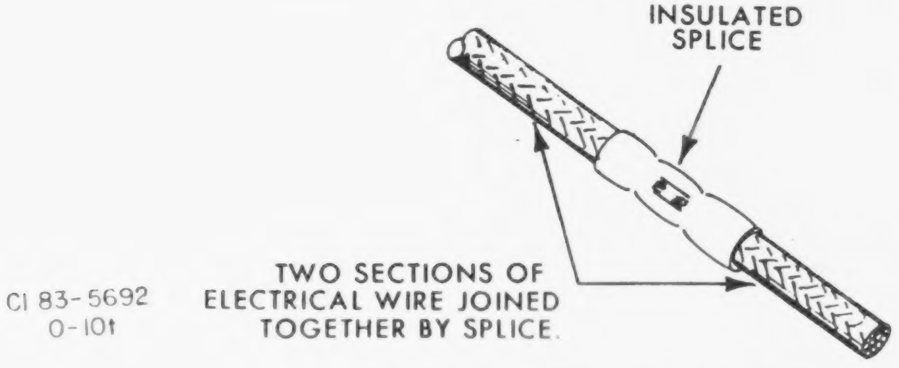
Answer to Frame 4: 1. d

Frame 5



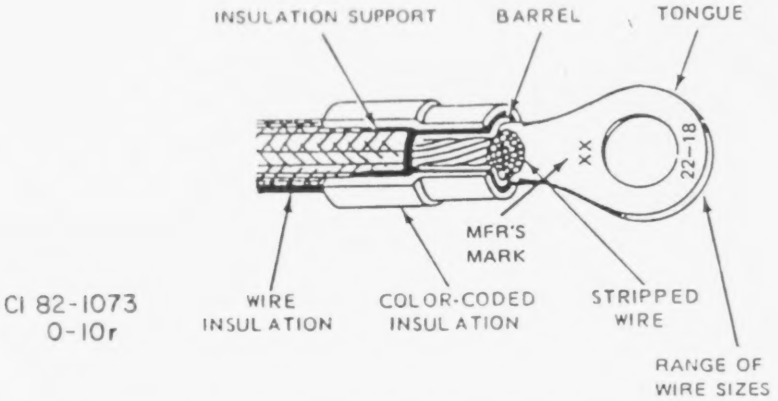
TYPICAL INSULATED TERMINAL LUG
INSULATED ELECTRICAL WIRE
CI 82-3437
0-10r

Figure 5. Typical Insulated Terminal Lug.



INSULATED SPLICE
TWO SECTIONS OF ELECTRICAL WIRE JOINED TOGETHER BY SPLICE.
CI 83-5692
0-10t

Figure 6. Insulated Splice.



INSULATION SUPPORT
BARREL
TONGUE
XX
22-18
MFR'S MARK
CI 82-1073
0-10r
WIRE INSULATION
COLOR-CODED INSULATION
STRIPPED WIRE
RANGE OF WIRE SIZES

Figure 7. Preinsulated Terminal Lug--Cutaway.

Solderless Terminal Lugs and Splices, Figures 5, 6, and 7--Electrical wires terminated with solderless terminal lugs to permit easy and efficient connection to and disconnection from terminal boards, busbars and other electrical equipment. Solderless splices join electric wires to form permanent continuous runs.

Answer the following question.

1. Name the item that is used to terminate electrical wires for ease of maintenance.

   a. Soldering cut
   b. Terminal lug
   c. Cannon plug
   d. Splice

Answer to Frame 5: 1. __b__

Frame 6

Thermocouples--Used throughout the aircraft to detect and measure temperature changes. Thermocouples are prefabricated into spark plug gaskets, bayonets for insertion into oil sumps, and probes for use in exhaust stacks. These thermocouples are supplied with short leads, usually 12 inches long and end in terminal lugs. The installation mechanic fabricates extension leads to carry voltages generated by the thermocouple to the indicating instruments. The components of a thermocouple system are designed to have a high degree of accuracy; correct installation by a good mechanic will maintain this accuracy.

Mark the following True or False by checking true statements with a check mark in the space.

____ 1. Thermocouples can indicate altitude changes.

____ 2. The leads supplied with thermocouples are usually 12 inches in length.

____ 3. Thermocouples normally have a high degree of accuracy.

____ 4. Incorrect installation of a thermocouple by a mechanic should not affect its accuracy.

Answers to Frame 6: 1. ____, 2. __✓__, 3. __✓__, 4. ____

Frame 7

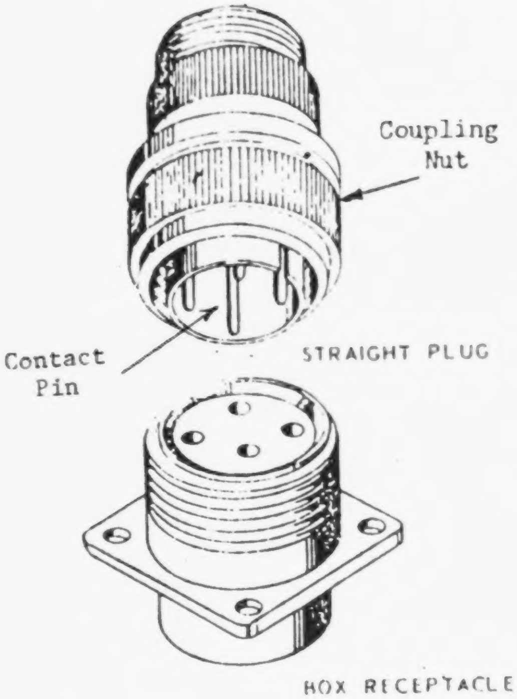


Figure 8. Common Connector.

Detachable connectors (cannon plugs) are used to join segments of electrical circuits installed in aircraft. These connectors must hold electrical circuits securely without undue voltage drop, under extreme vibration, rapid temperature changes, and vast altitude differences. A common connector consists of a plug assembly (see figure 8 for example) and a receptacle assembly that are fastened together by a coupling nut. You must be careful not to cross-thread, strip, or jam the nut. These connectors come manufactured with either the solder type or crimp type contact pins. When the solder type connectors are wired, a soldering iron and solder are the tools needed to do the job. Wiring the crimp type requires the proper crimping tool and special tools for inserting and extracting the contact pins.

Answer the following question by circling the correct answer.

1. What is the purpose of a cannon plug?

   a. Connect insulation
   b. Ground electrical circuits
   c. Join segments of electrical circuits
   d. Bond electrical circuits to aircraft structure

Answer to Frame 7: 1. c

Frame 8

Grounding--The electrical connecting of a conducting object to a primary structure (main frame, fuselage structure and wing structure of aircraft) for the return of current.

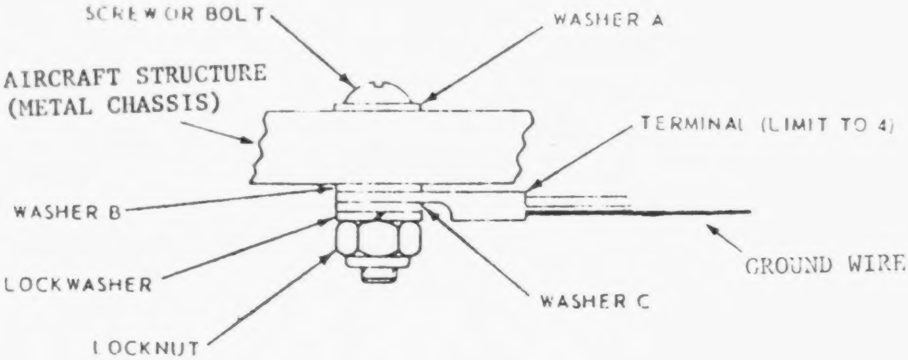

SCREW OR BOLT
WASHER A
AIRCRAFT STRUCTURE (METAL CHASSIS)
TERMINAL (LIMIT TO 4)
WASHER B
LOCKWASHER
LOCKNUT
WASHER C
GROUND WIRE

Figure 9. Grounding to Flat Surface.

In the wiring of practical circuits, one side of the voltage source is usually grounded. For the 120 VAC power line in residential wiring, the ground is actually earth ground, usually made by connecting a wire to a metal cold water pipe. For aircraft equipment, the ground is connected to a metal chassis (see figure 9) which is used as a common return for connections to the voltage source.

Answer the following question by circling the correct answer.

1. If you need to check a component for 28 VDC power, where would you ground the negative lead of the multimeter?

   a. Earth
   b. Aircraft structure
   c. Metal cold water pipe
   d. To the control switch

Answer to Frame 8: 1. b

Frame 9

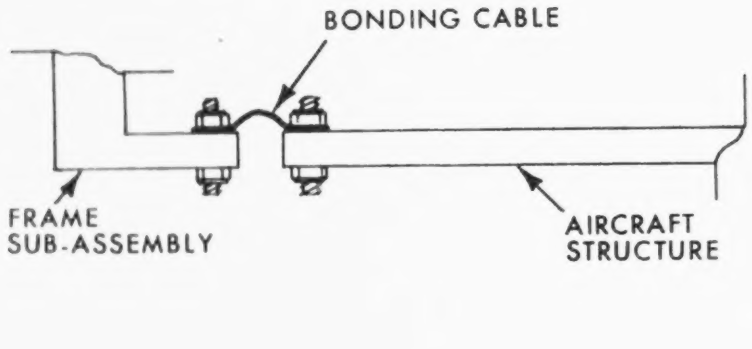


Figure 10. Bonding.

Bonding, Figure 10--The electrical connecting of two or more conducting objects not otherwise adequately connected.

Bonding is a system of connections which insure that the metal parts (structure, components, etc.) of an aircraft form a continuous electrical unit, thus preventing the arcing of static electricity.

Bonding connects the metal parts of the aircraft with flexible conductors so that all parts will have the same voltage or potential. Where connection is made by aluminum or copper jumpers to structure of dissimilar material, a washer of suitable material is installed between the dissimilar materials so that any corrosion which may occur will occur in the washer, which is expendable, rather than in the structure which is not expendable.

Answer the following question by circling the correct answer.

1. The metal parts of the aircraft are bonded together with flexible conductors so that all parts will have the

   a. ability to increase desired RF potentials.
   b. ability to increase a static charge.
   c. same resistance or power source.
   d. same voltage or potential.

Answer to Frame 9: 1. d

Frame 10

Because of the large amount of electrical components required on an aircraft, there are a lot of wires running everywhere. If nothing was done to organize and secure these wires, their ability to resist the elements and ease of working with them would not be up to acceptable standards.

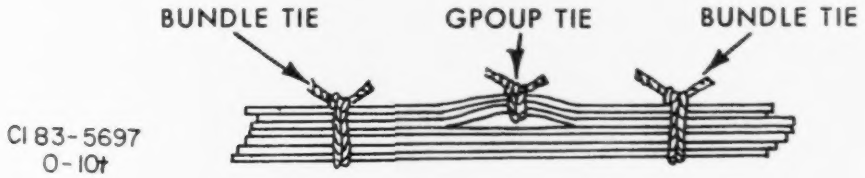

BUNDLE TIE
GPOUP TIE
BUNDLE TIE
CI 83-5697
0-10t

Figure 11. Croup and Bundle Ties.

Tying, Figure 11--The securing together of a group or bundle of wires with individual ties at regular intervals around the group or bundle.

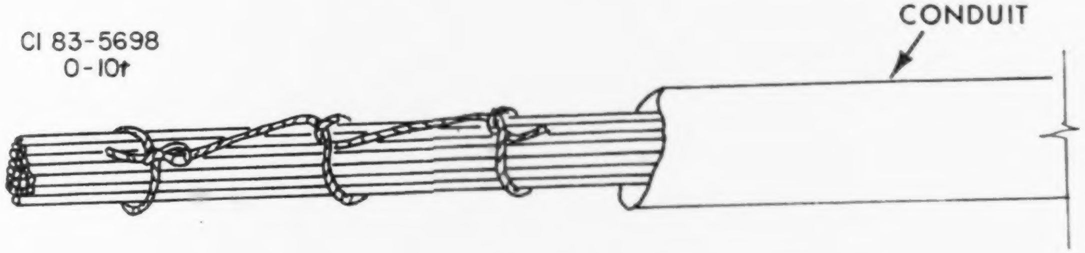

CI 83-5698
0-10t
CONDUIT

Figure 12. Single Cord Lacing.

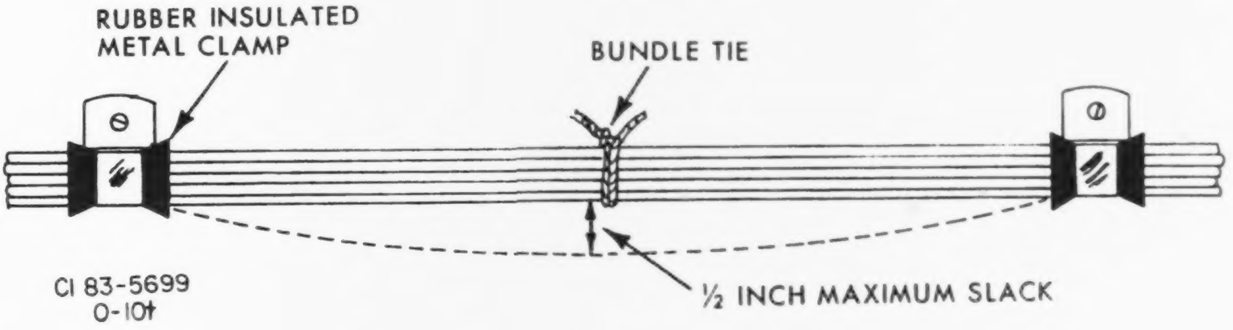
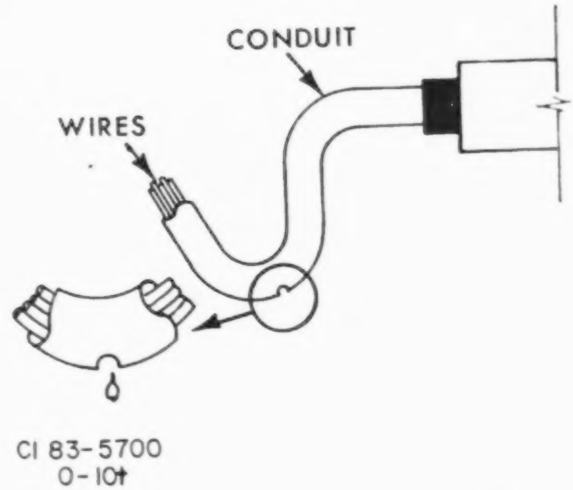

RUBBER INSULATED
METAL CLAMP
BUNDLE TIE
CI 83-5699
0-10t
½ INCH MAXIMUM SLACK

Figure 13. Slack Between Supports

Lacing, Figures 12 and 13--The securing together of a group or bundle of wires, installed inside enclosures, by means of a continuous cord forming loops at regular intervals around the group or bundle. Except for enclosures, wire groups or bundles should not be laced.



DRAINAGE HOLE 1/8" DIA
AT LOWEST POINT IN TUBING.
MAKE HOLE AFTER INSTALLATION
IS COMPLETE AND LOWEST POINT
IS FIRMLY ESTABLISHED.

Figure 14. Drainage Hole in Low Point of Conduit.

Conduit, Figure 14--A pipe or tube for protecting electrical wiring.

Wire Group--Two or more wires tied or laced together to give identity to an individual system.

Wire Bundle--Two or more wires or groups tied or laced together to facilitate maintenance.

Three other ways of organizing and securing wires are as follows: (1) nylon cable straps, (2) pressure-sensitive tape, and (3) cable clamps.

Quick Overview

1. Aircraft wiring is usually stranded for flexibility.
2. Shielded cable provides a barrier against electrostatic interference.
3. Electrical wires are terminated with solderless terminal lugs for ease of maintenance.
4. Thermocouples are used throughout the aircraft to detect and measure temperature changes.
5. Detachable connectors are used to join segments of electrical circuits without undue voltage drops. The most common type is the cannon plug.
6. For aircraft equipment, the ground is connected to the metal chassis which is used as a common return for connections to the voltage source.
7. Bonding connects the metal parts of the aircraft with flexible connectors so that all parts will have the same voltage or potential.
8. Tying and lacing are two of the most common types of securing wiring.

Frame 11

Wiring maintenance is an important part of environmental systems. In some cases, one wire can prevent an aircraft from flying. This is why it is very important for you to retain your basic wiring maintenance knowledge.

NO RESPONSE REQUIRED

Technical Training

Aircraft Environmental Systems Mechanic

OPERATION OF AN AIRCRAFT AIR CONDITIONING SYSTEM MOISTURE SEPARATOR

10 February 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: 9.3

OBJECTIVE

Relate components of the moisture separator to their operation with 80% accuracy.

INSTRUCTIONS

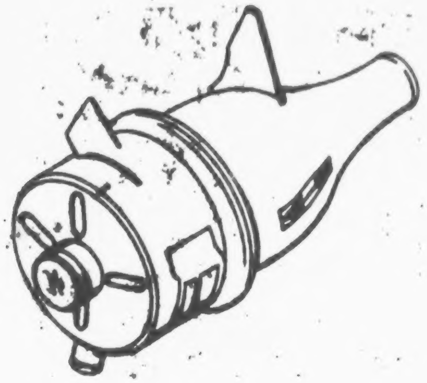
This program presents information in small steps called "frames." After each step you are asked to select the correct statement, match some statement, or respond to the information presented in some other way. Read the material presented and make your response on the response sheet. DO NOT MARK IN THIS TEXT. Compare your responses with answers at the top of even numbered pages. If you are wrong, read the frame again.

Supersedes 3ABR42331-PT-304, 5 February 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 350; DAV - 1

Frame 1

An aircraft moisture (water) separator in an air conditioning system is made to remove 70 to 85% of the water from the air that is passed through it. The water is in the form of a vapor. The size and shape of the separator is determined by (1) the size of the cabin in the aircraft (2) the amount of air put out by the air conditioning system, and (3) the location of the separator in the system.

Let us consider the unit used by a typical cargo aircraft. This unit is about two feet long and 12 inches in diameter. This cone-shaped unit has an opening at both ends; one for air IN and one for air OUT. We are mostly interested in how it works inside. The complete unit is shown in the diagram.



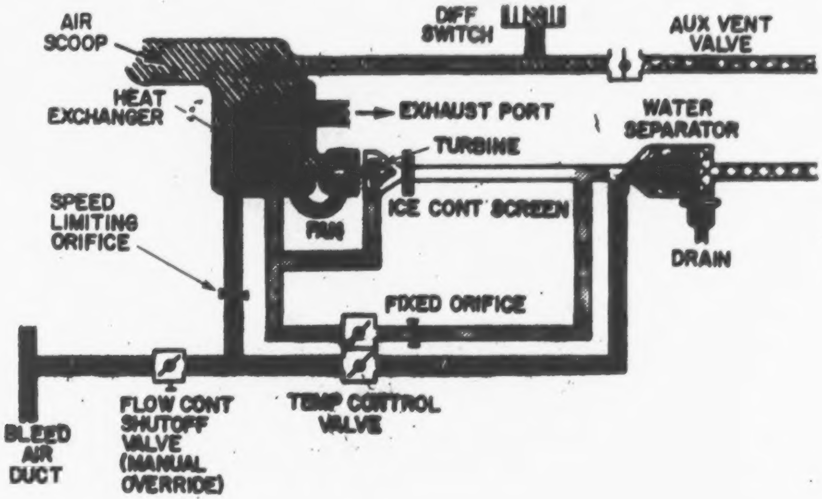
Answer the statements as true (T) or false (F).

1. All water separators are the same size.
2. Size determines the basic operation of a moisture separator.
3. The moisture separator removes a large percentage of the water vapor from the conditioned air.

Correct Responses to Frame 1: 1. F, 2. F, 3. T.

Frame 2

In the diagram, you can see the location of the moisture separator in the system. Note, all the conditioned air must pass through the separator. All aircraft have the separator located downstream of the refrigeration unit. You will recall that cold air does not hold as much water as warm air. So, due to the fast cooling of the air through the turbine, the water vapor in the air will condense into a fog. This fog will form water droplets, and in some cases, snow or ice crystals. We do not want this fog, rain, snow or sleet to blow into the cabin. It is removed by the moisture separator.


AIR SCOOP
DIFF SWITCH
AUX VENT VALVE
HEAT EXCHANGER
EXHAUST PORT
WATER SEPARATOR
TURBINE
SPEED LIMITING ORIFICE
ICE CONT SCREEN
FAN
DRAIN
FIXED ORIFICE
BLEED AIR DUCT
FLOW CONT SHUTOFF VALVE (MANUAL OVERRIDE)
TEMP CONTROL VALVE

Complete the statements.

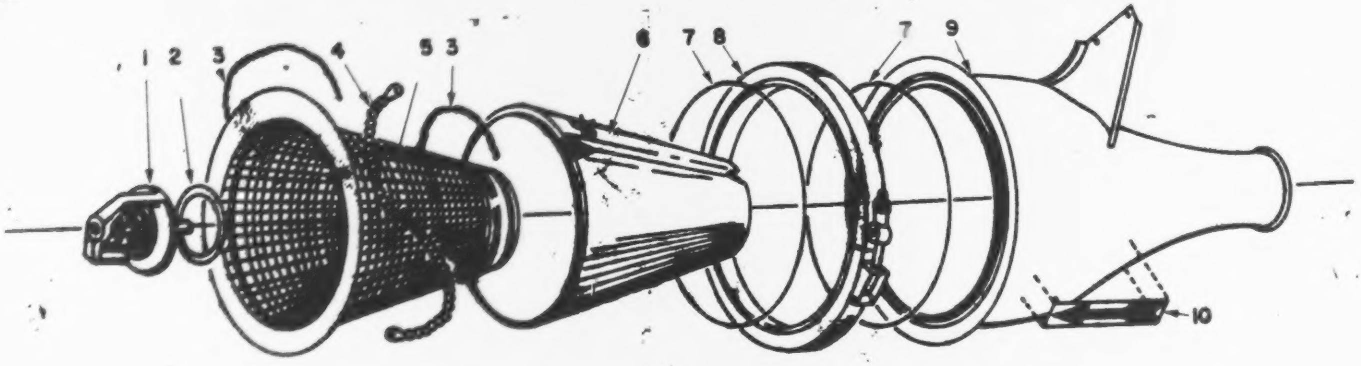
1. Moisture separators are always __________ of the turbine.

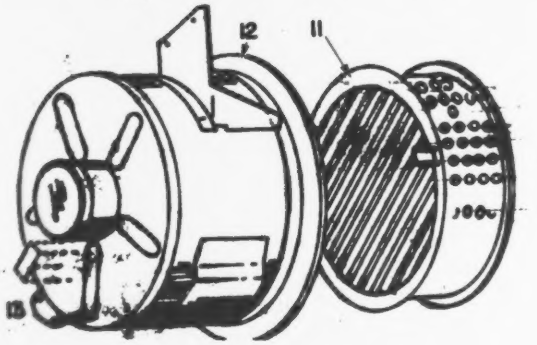
2. _________% of the conditioned air passes through the moisture separator.

3. _________ air holds more water than ___________ air.

Frame 3

Identification of parts of a moisture separator.





1. Bypass valve
2. Seal
3. Springs (2)
4. Chain
5. Support
6. Conical condenser
7. Rubber O-ring seals (2)
8. V-band clamp
9. Shell assembly (inlet end)
10. Arrow
11. Eliminator assembly
12. Shell assembly (outlet end)
13. Drain

Study the illustration until you are able to identify each part from memory.

NO RESPONSE REQUIRED

Correct Responses to Frame 2: 1. downstream, 2. 100, 3. warm/cold.

Correct Response to Frame 3: None Required.

Frame 4

Grooved flanges are welded to both parts of the shell assembly, where the two shell halves join. O-ring seals are installed in these grooves to stop air and water leakage during operation. The air inlet and outlet connections (see illustration in frame 3) are beaded and fastened to the rest of the air conditioning ducting by rubber sleeves. The sleeves are held in place by clamps. Welded on the side of the shell assembly are brackets that allow the entire assembly to be bolted to the aircraft. An arrow on the shell shows which way the air flows. Aligning pins on the flanges are used to properly fit the two halves of the shell assembly together.

Complete the statements.

1. The O-ring ________ prevents air and water leakage at the clamp connection.

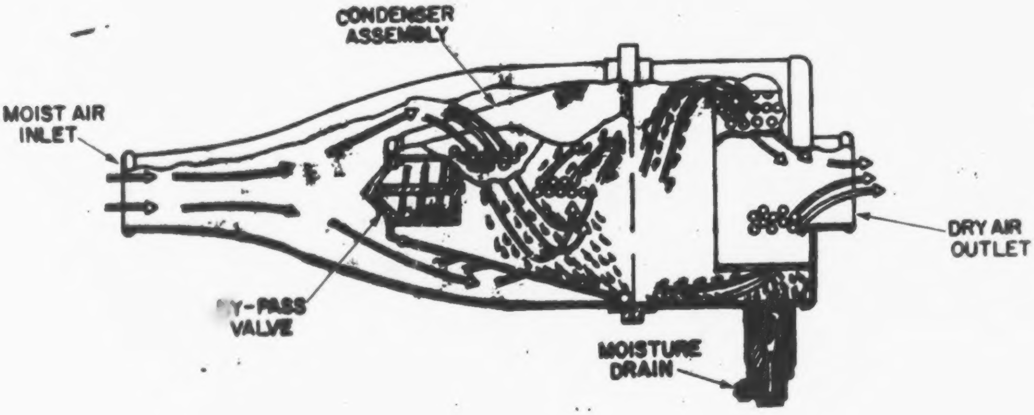
2. The arrow on the shell assembly indicates ____________ of ____________ ______________.

3. The moisture separator is bolted to the __________________.

4. The inlet and outlet connections are beaded and fastened to the air conditioning ducting by rubber __________________.

Frame 5

The conical condenser fits snugly over the support. It is held in place by a spring at the small end and a spring and chain assembly at the large end. As the cold air comes off the turbine, the water vapor condenses into a fog made up of small water droplets. The condenser will cause these small droplets to condense into large droplets (fuse together).



The air goes through the condenser and hits the support. The support is louvered and will give the air a swirling motion as it goes through. This swirling will cause the water droplets to be thrown outward and against others, forming still larger drops. This water and air mixture then goes through the eliminator assembly. The drops of water strike and run down the vertical rods of the eliminator to the bottom of the shell assembly. The water collects here and is drained overboard.

Complete the statements.

1. The conical condenser fits __________ over the support.
2. The conical condenser __________ the water droplets ______________.
3. The conical condenser gathers __________ water droplets into ____________ water droplets.
4. The conical condenser fits over the ________________.
5. The louvered support gives the air a ______________ motion.
6. The __________ assembly takes the water out of the air.

Correct Responses to Frame 4: 1. seal, 2. direction/air flow, 3. aircraft, 4. sleeves.

Correct Responses to Frame 5: 1. snugly, 2. fuse/together, 3. tiny/larger, 4. support, 5. swirling, 6. condensor assembly.

Frame 6

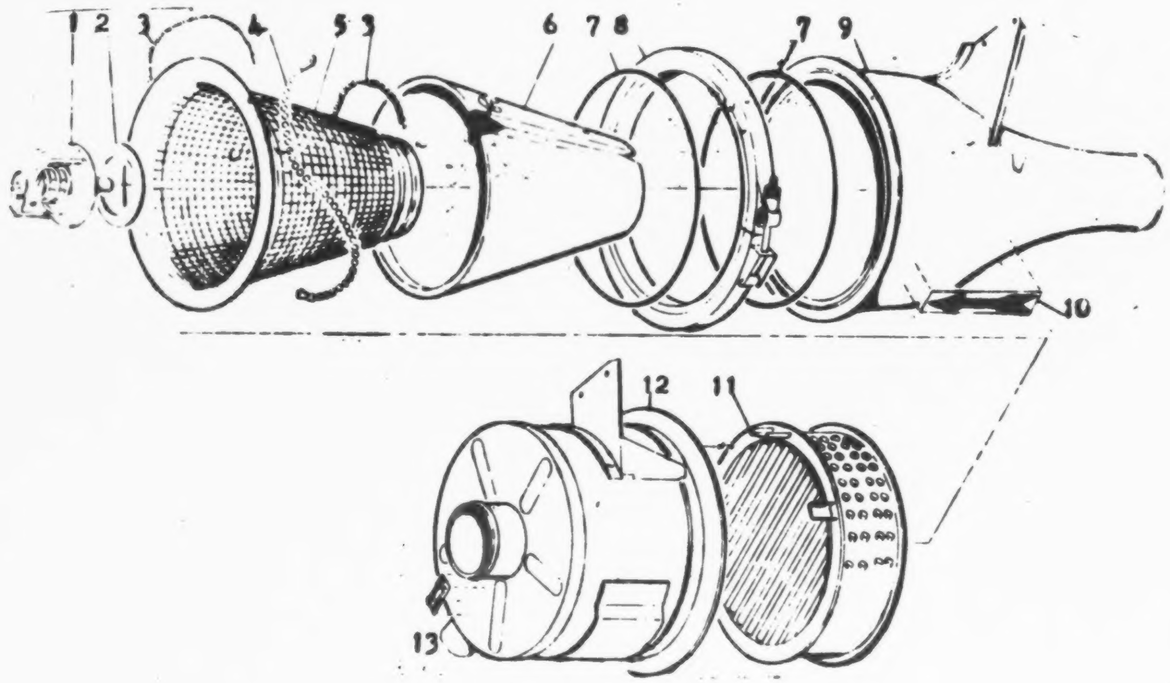
A bypass valve is in the small end of the support (see the illustration in frame 5). This is the end of the support that first receives the flow of air. This air, as you will recall, comes from the turbine and is quite cold. The temperature of the air might even drop below the freezing point. If this occurs, the water condensed by the conical condensor might turn into a solid sheet of ice. The ice would cause the flow of air to stop. This is where the bypass valve comes in. Since we MUST have a flow of air to the cabin, this safety device was built in. The bypass valve works like a pressure relief valve. The bypass valve is held closed by a spring. In this closed position the valve will force all of the air to flow through the conical condensor. The air can then rid itself of moisture. If the conical condensor freezes over pressure will build up, upstream of the bypass valve. When the air pressure is more than the pressure of the bypass valve spring, the bypass valve opens and lets the air pass through. But, this time the air carries with it any moisture that is generated from the refrigeration process. Keep in mind, the flow of air to the cabin is a MUST, whether or not it carries moisture.

Complete the statements.

1. The bypass valve is installed in the ____________ end of the support.
2. The bypass valve is held closed by a ____________________.
3. Air flow to the cabin is a __________________.

Frame 7

Identify each part of the moisture separator. If in doubt, go back to Frame 3 and review.



1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________
9. ____________________
10. ____________________
11. ____________________
12. ____________________
13. ____________________

Conical condenser
Support
V-band clamp
Drain
Chain
Springs (2)
Shell assembly (inlet)

Rubber O-ring seals
Eliminator assembly
Seal
Shell assembly (outlet)
Bypass valve
Arrow

Check your responses for Frames 6 and 7 on page 8. If you missed any of the questions in Frame 7, check yourself by rereading the frame containing the information asked by the matching items. If you need help, ask your instructor.

Correct Responses to Frame 6: 1. small, 2. spring, 3. MUST.

Correct Responses to Frame 7:

1. Bypass valve
2. Seal
3. Springs (2)
4. Chain
5. Support
6. Conical condenser (sock)
7. Rbber 0-ring seals (2)
8. V-band clamps
9. Housing (inlet end)
10. Arrow
11. Eliminator assembly
12. Housing (outlet end)
13. Drain

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-WB-304
11 February 1983

MAINTENANCE OF MOISTURE SEPARATORS

OBJECTIVES

Using a TO, applicable handtools and equipment, disassemble, inspect, and reassemble a moisture separator with a maximum of two (2) instructor assists.

> Note: An instructor assist is defined as limited aid, such as technical direction or explanation or technical order interpretation given a student who can proceed no further on his/her own.

EQUIPMENT

TO 1-1A-8, Sections 16 and 18
TO 15A7-2-11-3
Moisture Separator Assembly
Rachet Handle, 3/8" Drive
Socket, 3/8" X 3/8" Drive
Duckbill Pliers
Side-cutter Pliers (Dikes)
Four (4") Common Screwdriver
Safety Wire, .032 Size, Steel
Safety Goggles

INSTRUCTIONS

As this workbook progresses, you will be directed to locate certain items, follow directions, or do certain tasks. At all times there will be an instructor available to help you. Be sure to ask him any questions you might have about the process of maintaining this item. Get the equipment you will need at this time.

INFORMATION

There are several reasons why you need to work on the moisture separator. During certain periodic and hourly inspections you will need to clean the conical condenser. While troubleshooting a maintenance write-up on the air conditioning system you may need to work on the moisture separator. The proper and timely maintenance of the moisture separator is one of your responsibilities.

Supersedes 3ABR42331-WB-304, 19 November 1980, which may be used until existing stocks are exhausted.   RGL: N/A
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 350; DAV - 1

Designed for ATC Course Use. Do Not Use on the Job.

In this workbook, you will be taught how to maintain and inspect the moisture separator.

When you work with fiberglass, as is this condenser bag, you must wear protective clothes and rubber gloves. To make the job easier for you and to save the Air Force money, the fiberglass bag has been replaced with a plastic bag here at school. You will not need to wear protective clothes and gloves. Also, you will not wash the bags, as they do not get dirty here in school. If washed too much the bags would deteriorate fast.

PROCEDURE

1. All maintenance made on an aircraft, or a part from an aircraft must be done to technical order (TO) specifications. Open the TO to page 1.

a. Write the part number of each water separator that this TO will cover. ______________________________

b. On the moisture separator you have, find the data plate and list the following:

(1) Stock number ____________________

(2) Part number ____________________

(3) Serial number ____________________

c. Does the part number of the moisture separator match one of the parts numbers listed on the front page of the TO?

(Yes) ____ (No) ____

Note: If the parts numbers do not match, you have the wrong TO. If the parts numbers do match, you have the correct TO. You may start with the tasks in the workbook. If the numbers did not match, tell the instructor.

From this point on, make sure you read and fully understand each step before you do the task. Watch how each part comes off, as you will need to assemble it by yourself. If you have questions, be sure to ask the instructor.

2. Use the IPB (figure 3) of the TO and the instructions given to disassemble the moisture separator assembly.

a. Start by removing the V-band clamp (12) that holds the two halves together.

b. Remove the spring (18) from the small end of the conical condenser support assembly (35).

c. Remove the conical condenser from the support assembly and lay it on the bench in front of you.

Warning: Safety goggles must be worn when you work with safety wire.

d. Use the dikes to cut the safety wire from the six screws that hold the bypass valve (24) to the support. Remove the screws and the bypass valve.

Note: Do not try to disassemble the bypass valve.

e. It is now time to inspect each part. Use the information found in the inspection section (paragraph 4) of the TO to make a thorough inspection of each part. List 3 for each area below.

Inspection Findings

Drain (6 - 11) ______________________________

Shell assembly (15 - 36) ______________________________

Bypass valve (24) ______________________________

Threaded parts ______________________________

Nonkitted parts ______________________________

Note: A kitted part is one that comes in an overhaul or repair kit. Nonkitted parts are large parts that must be ordered separately.

f. After you have made the inspection, tell the instructor.

3. Reassemble the moisture separator.

a. Install the bypass valve on the support assembly, then safety wire the screws. Have the instructor inspect your safety wire job before you go to the next step.

b. Slide the conical condenser over the support and install the spring on the small end.

c. Install the conical condenser support assembly back in the inlet shell assembly.

d. Use the alignment pin and hole to be sure the shell assemblies are aligned. Be sure the O-ring seals (13) are in the grooves.

e. Install the V-band clamp and tighten the nut with the rachet wrench.

f. Safety-wire the V-band clamp.

g. Have the instructor check your work.

5. In part two of the project you will use an AFTO Form 349 to account for your time and the work you did. The instructor will issue the materials you need.

6. After you have finished, ask the instructor to check your work.

Assists: 1. __________ 2. __________

INSTRUCTOR'S SIGNATURE ______________________

PROGRAMMED TEXT

C3ABR42331-PT-305

Technical Training

Aircraft Environmental Systems Mechanic

MAINTENANCE OF BLEED AIR DISTRIBUTION DUCTING

10 February 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: 9.9

OBJECTIVES

1. Identify the types of repairs that can be made on bleed air duct insulation with 80% accuracy.

2. Identify methods used to slow corrosion on bleed air ducting with 80% accuracy.

3. Relate types of cleaning agents and lubricants to their uses with 80% accuracy.

INSTRUCTIONS

This text presents material in small steps called "frames." After each frame you will find a number of statements and you are asked to select the true statement(s) from the list. The answers to the correct statements can be found on the top of the next page. DO NOT MARK IN THIS TEXT. If you select the correct answer, continue to the next frame. If you choose the wrong answer, correct yourself before continuing.

As you read the text, ducting will be available in the classroom for your inspection.

Supersedes 3ABR42331-PT-305, 5 February 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 350; DAV - 1

Let us consider some of the things that damage bleed air ducting. Two of the main things are vibration and people. Vibration can be kept to a minimum by proper duct mounting. Most damage is caused by mechanics that walk on or hit the ducting with hammers, screwdrivers, etc. These careless actions dent and twist the ducting. The mechanics can also cause damage to the ducting by overtightening clamps, nuts, and bolts. If these clamps are too tight, a duct can be cracked. If the clamps are too loose, they may leak and, in time, will cause a hole to burn in the duct flange.

Answer each of the statements as true (T) or false (F).

1. Mechanics cause the most damage to a duct.
2. If the clamps are too tight, they can crack the duct.
3. Nothing happens if clamps are not torqued properly.
4. The mechanic should never step on ducting.
5. If the clamps are too loose, they could cause leaks.

Answers to Frame 1: 1. T 2. T 3. F 4. T 5. T

Frame 2

Insulation around the ducting is used for several reasons. It prevents the mechanics from burning themselves, and protects wiring and equipment near the ducting from getting too hot and then burning. This insulation is fireproof, and the cover is watertight and airtight. It is made of fiberglas cloth.

The cover of the insulation is what you will be repairing in the field.

Answer each of the statements as true (T) or false (F).

1. Insulation is used to prevent burns.

2. The insulation is made of fiberglas cloth.

3. The insulation is not watertight.

4. The insulation is airtight.

5. The cover of the insulation is repaired in the field.

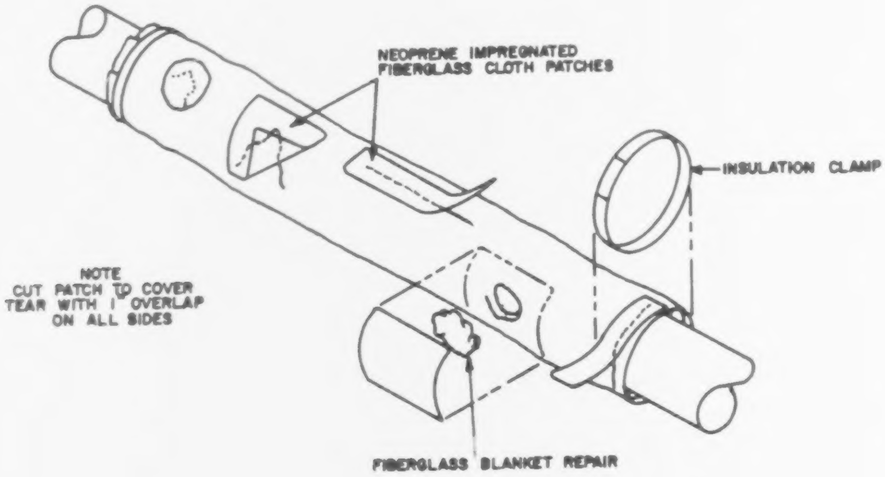
Answers to Frame 2: 1. T 2. T 3. F 4. T 5. T

Frame 3

The three (3) types of insulation repairs that can be made are cemented, sewed, and spot-welded.

Let us first talk of the cemented repairs. The same type of material that is patched is also the patching material.

As shown in the figure, be sure you cut the patch for cementing at least one inch larger on all sides. This allows the patch to hold in place when the cement (glue) is put on the patch.


NEOPRENE IMPREGNATED FIBERGLASS CLOTH PATCHES
INSULATION CLAMP
NOTE
CUT PATCH TO COVER TEAR WITH 1" OVERLAP ON ALL SIDES
FIBERGLASS BLANKET REPAIR

Answer each of the statements as true (T) or false (F).

1. Cemented, sewed, and spot-welded are types of insulation repair.
2. Fiberglas cloth is used to repair fiberglas insulation.
3. The patch is smaller than the rip.
4. Cement (glue) is used to repair cemented type repairs.
5. The patch is larger than the rip.

Answers to Frame 3: 1. T 2. T 3. F 4. T 5. T

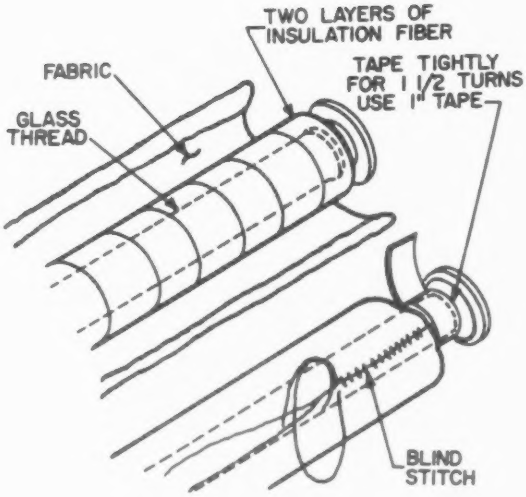
Frame 4

The sewed insulation is shown in the top figure. Fiberglas thread is used to fix this type of insulation rip. A curved needle is used to make a blind stitch.

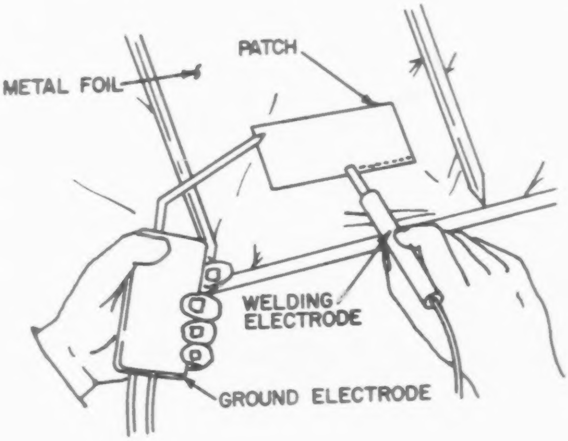
When metal foil insulation must be fixed, a spot welder is used as shown in the bottom figure. A metal foil patch is put directly on the metal foil insulation.

Answer each of the statements as true (T) or false (F).

1. Fiberglas thread and a curved needle are used to sew the insulation.
2. The ground electrode must make contact with the patch while the welding electrode is being used.
3. The metal foil patch must be larger than the rip.


TWO LAYERS OF INSULATION FIBER
FABRIC
GLASS THREAD
TAPE TIGHTLY FOR 1 1/2 TURNS USE 1" TAPE
BLIND STITCH

Sewed Insulation Repairs


METAL FOIL
PATCH
WELDING ELECTRODE
GROUND ELECTRODE

Repairing Metal Foil Insulation

Answers to Frame 4: 1. T 2. T 3. T

Frame 5

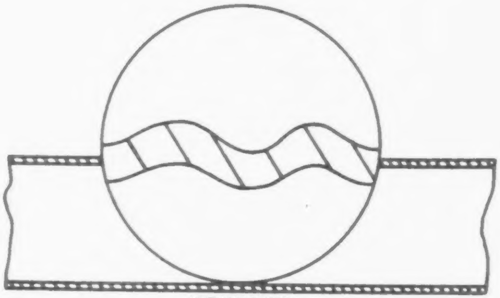
Wrinkles, dents, and scratches, shown in the figure, are the three types of damage that occur to ducting.

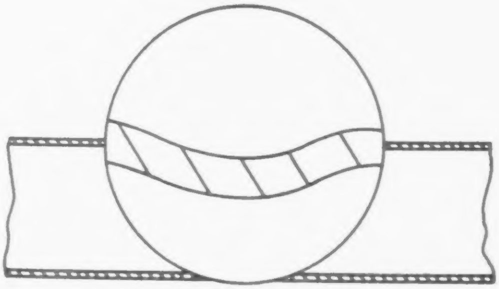
Wrinkles and dents will slow the flow of air and cause hot spots in the ducting. Wrinkles can not be less than 1/2" long when more than 1/8" deep. Dents can not be more than 1/16" deep when less than 5/8" long. These limits are set for if the dent or wrinkle were deep and too short, the sharp metal crease that goes in the airstream would disturb the flow of air beyond acceptable limits. A scratch can not be more than 2/1000" (.002") deep. If a scratch is too deep the scratch will weaken the duct wall and leakage can occur.

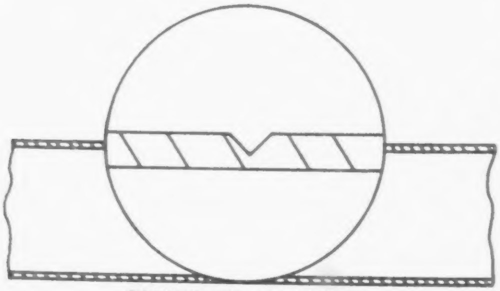
It is not necessary to remember the damage limits, but you should remember it does not take much damage before the duct must be replaced.

Answer each of the statements as true (T) or false (F).

1. The three categories of damage are wrinkles, dents, and scratches.
2. Wrinkles slow the airflow and cause hot spots.
3. A deep scratch will weaken the duct wall.
4. Scratches are likely to cause ducting to leak.


WRINKLES


DENTS


SCRATCHES OR GOUGES

Answers to Frame 5: 1. T 2. T 3. T 4. T

Frame 6

There are just a few things to keep in mind about ducting and its repair. When working with a screwdriver make sure it does not slip and damage the ducting or the insulation. When in doubt about allowable damage, always check the TO. Also make sure you use the proper torque on all clamps and bolts.

It is not an easy job to replace ducting, so BE CAREFUL when working with it.

No Response Required

Frame 7

Corrosion Control

Now let us see what happens to ducting if corrosion sets in and how corrosion can be slowed. Corrosion in aluminum and its alloys looks like a spot of dirty, dust-like, white powder that is on the surface of the metal. This gets progressively worse as deterioration increases, and the metal may weaken to the failure point. So, you can see why the ducting must be inspected frequently for signs of corrosion.

To slow up corrosion, several things can be done. The metal can be painted, waxed, oiled, or coated with a metal that corrodes slowly. The process used most is to coat the ducting with a metal that corrodes slowly. This process is known as anodizing, aluminum cladding, chrome plating, or copper plating to name a few.

Answer each of the statements as true (T) or false (F).

1. Corrosion appears as a dust-like white powder.
2. Corrosion can weaken the metal.
3. Ducting never needs to be inspected for corrosion.
4. Coating the metal with a metal can be called aluminum cladding.
5. Painting of the ducting slows down the corrosion process.

Answers to Frame 7: 1. T 2. T 3. F 4. T 5. T

Frame 8

Never underestimate the importance of anticorrosion precautions. Any corrosion affecting the parts of an aircraft affects the safety of an entire aircraft.

No Response

Fee! Fi! Fo! Fum!
PLEASE PASS THE USAF'S
ALUMINUM!

THE CORROSION MENANCE

Frame 9

Cleaning Agents

Some of the types of cleaning agents used in the Air Force are Stoddard solvent, Flash solvent, Type I solvent, Type II solvent, Perchloroethylene, Tetrachloroethylene, and Trichloroethylene.

Trichloroethylene is used more than the other cleaning agents. It is used to clean oxygen parts, degrease bearings, clean motor gear trains, etc. Do not try to clean electrical wiring with trichloroethylene as the wire insulation will deteriorate. Electrical parts should be cleaned with a lint free cloth slightly moist with cleaning solvent.

Answer each of the statements as true (T) or false (F).

1. Stoddard solvent is considered to be a cleaning agent.

2. Electrical wiring may be cleaned with trichloroethylene.

3. Flash solvent is NOT a cleaning agent.

4. Type I and Type II solvents are cleaning agents.

WARNING

If solvents are used in a closed space, good ventilation must be used to keep the concentration of contaminants in the air from becoming hazardous to health. The base medical service will check for the correct protective measures.

Answers to Frame 9: 1. T 2. F 3. F 4. T

Frame 10

Lubricants: When on the flight line you will use many different types of oil, grease and lubricants. We list a few of them that you will use.

The first one is Specification MIL-L-7645, Lubricating Grease. This is a semisolid, noncorrosive, mild extreme pressure lubricant. It is used for gears, screws and threaded parts. It is used for greater loads than petroleum oils. The grease is not an extreme pressure or "Hypoid" lubricant.

Specification MIL-G-4343, Grease, Pneumatic System is used as a lubricant between rubber and metal parts. It may be used for pneumatic systems, pressurized cabin bulkhead grommets and other mechanisms.

Answer each of the statements as true (T) or false (F).

1. Specification MIL-L-7645 is a single-grade of aircraft turbine lubricating oil.
2. MIL-G-4343 may be used for lubricating grommets between pressurized cabin bulkheads.
3. MIL-L-7645 is a noncorrosive lubricant.
4. MIL-L-7645 is considered to be very corrosive.

Answers to Frame 10: 1. F 2. T 3. T 4. F

Frame 11

Two of the most used lubricating oils are Specification MIL-L-007808F and MIL-L-6085. Specification MIL-L-007808F lists oils of a single-grade. These oils are used in turbine engines and helicopter transmissions. Specification MIL-L-6085 lists oils that are used in aircraft instruments, electronic equipment, or where low evaporation oil is required for both high and low temperature operations. These oils can be used where oxidation and corrosion resistance is desirable.

Answer each of the statements as true (T) or false (F).

1. MIL-L-007808F lubricating oil covers a single-grade of aircraft turbine lubricating oil.

2. MIL-L-007808F lubricating oil is intended for use in specific turbine engines and helicopter transmissions.

3. MIL-L-6085 is considered to be a low evaporating lubricating oil.

4. MIL-L-6085 lubricating oil may not be used where high or low temperatures are applicable.

5. MIL-L-6085 lubricating oil is not a corrosion resistance oil.

Answers to Frame 11: 1. T 2. T 3. T 4. F 5. F

Frame 12

Keep in mind, these are not all of the lubricants that are used in the Air Force. When you need any lubricant for repair jobs, refer to a technical order for the correct specification.

No Response Required

SERVICE TEST
PROGRAMMED TEXT
C3ABR42331-PT-305A

Technical Training

Aircraft Environmental Systems Mechanic

CLEANING AGENTS AND LUBRICANTS

3 November 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

OBJECTIVE

Relate types of cleaning agents and lubricants to their uses answering a minimum of 4 of 5 questions correctly.

Note: If there is an asterisk (*) next to a word you are to go to the GLOSSARY OF TERMS in the back of this PT. It will help you in understanding some of the words used in this PT.

INFORMATION

The answers to the frames are located in the back of this PT.

This PT is made up of two parts. Part I applies to cleaning agents, types of soils, and solvents. Part II applies to lubricants/oils and greases.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 250; DAV - 1

CLEANING AGENTS AND LUBRICANTS

Frame 1

Proper operation of aircraft systems depends on the parts being cleaned and having the proper lubrication. Serious damage can result if the wrong type of lubricant/oil is used in a system. The cleanliness of parts and their internal operation is also a critical factor. If parts are allowed to get dirty, they will not function in the way they were designed. They may have excessive wear and finally fail altogether. Therefore, we must learn to identify the proper cleaning agents and lubricants used in the performance of our duties.

Let us begin our discussion with cleaning agents.

//////////

NO RESPONSE REQUIRED

PART I

CLEANING AGENTS

Frame 2

Cleaning is a broad term covering methods and materials needed to remove the soils from a surface. Selection of an appropriate cleaning method in any given case will depend on three important factors:

1. Type and amount of soil
2. What the item is made of and what the surface is like
3. Just how clean it must be

Proper cleaning will extend service life, increase reliability, provide a greater margin of safety, decrease the overall operation and maintenance cost, and maintain the appearance of the equipment.

//////////

Fill in the blanks:

Selection of an appropriate cleaning method in any given case will depend on three important factors:

1. ________________________________
2. ________________________________
3. ________________________________

Frame 3

Soils that collect on a surface may be placed in three classes:

- Oily soils
- Semi-solid soils
- Soils containing solids

We will begin our lesson with oily soils.

Oily Soils

(Examples: hydraulic fluid, lubricating oil, light oil, soft films of corrosion preventing compound, etc.) When present as thin films or small residues, and when not very *viscous in nature, these soils may be removed by *alkaline cleaners. On more stubborn areas, solvent specification P-D-680, Type II may be used. (Cleaners and solvents will be discussed later in this text.) Usually, the longer a soil remains on a surface and the higher the temperature, the more difficult the soil is to remove. A great deal of trouble can be prevented by cleaning off soil as soon as possible.

//////////

1. Name three classes of soils:

a. ______________________________

b. ______________________________

c. ______________________________

2. Answer the statement as true (T) or false (F).

Usually, the longer a soil remains on a surface, the lower the temperature, the more difficult the soil is to remove. ______

Frame 4

(Examples: viscous oils, greases, hard film corrosion preventing compound, etc.) These soils are usually removed with either alkaline, or solvent emulsion cleaners. Heavy deposits of this type are usually best removed by using a solvent first, then applying an alkaline cleaner.

//////////

Answer each of the statements as true (T) or false (F).

1. Semi-solid soils are usually removed with either alkaline or P-D-680, Type II. ______

2. Heavy deposits of this type are usually best removed with soap and water. ______

Frame 5

(Examples: mud, carbonized oils, corrosion products (*scale) etc.) These soils are usually the most difficult to remove. Removal of these soils usually takes a combination of solvent soaking, alkaline pressure spray, and scrubbing (mechanical agitation and, in the case of corrosion products, acid pickling). As mentioned before, old soils increase the difficulty of removal.

//////////

Fill in the blanks:

Soils containing solids are usually the most ____________ to ____________. Aging soils ____________ the difficulty of ____________.

Frame 6

Before using any type of cleaning agent, CONSULT THE APPROPRIATE TECHNICAL ORDER for the correct procedure and agent to use when cleaning.

There are many different types of cleaning agents, but we will only discuss four of them. We will start our discussion with alkaline cleaners.

Alkaline Cleaners

This type of cleaner removes a soil by lifting it from the surface. After removing the soil from the surface, it may be carried in the body of the cleaner; it may separate, or in the case of fatty soils, it may react partially or completely with the cleaner and dissolve in the alkaline solution. Cleaners of this type usually have *constituents that aid in the lifting of soils from a surface, then breaking them up.

//////////

Answer the statement true (T) or false (F).

Cleaners of this type usually have components that aid in lifting soils from a surface. ______

Frame 7

Solvents

This type of cleaner removes a soil by dissolving the oily constituent of the soil, thus resulting in the solution leaving a thin film or residue of an oily nature. Removal of this oily film or residue is accomplished by using an alkaline cleaner.

The two most common solvents you will come in contact with as an environmental systems mechanic are:

- Specification P-D-680, Type II
- *Trichloroethylene

We will discuss each of these separately.

//////////

Answer each of the statements as true (T) or false (F).

1. Solvents remove a soil by dissolving the oily constituents of the soil. ______

2. Two most common alkaline cleaners you will come in contact with are specification P-D-680, Type II, and trichloroethylene. ______

Specification P-D-680, Type II

Specifications P-D-680, Type II, is very flammable and has a flash point of 138°F. It must NOT be used around flames or smoking areas. It is used to clean cabin pressure regulators, except the bellows assembly. It is also used when cleaning components and lines after the firing or *CB and *DB fire extinguishers.

WARNING

> Even though P-D-680, Type II, is a safety solvent, there are a few things you must know. Adequate ventilation MUST be provided when using this type of cleaning solvent. Also, avoid prolonged breathing of vapors and minimize skin contact.

The effects of being over-exposed to P-D-680, Type II, solvent can be very harmful to different parts of the body. If the solvent comes in contact with the eyes, it will cause irritation, redness and tearing. The prolonged breathing of vapors can cause dizziness, *asphyxiation, nasal and respiratory irritation, and *pneumonitis. Repeated skin contact will cause irritation, *defatting and *dermatitis.

All these effects can be prevented by using protective clothing, eye goggles, and an approved self-contained breathing aid, if prolonged exposure is required, and sufficient ventilation is not available.

//////////

Fill in the blanks:

1. The effects of overexposure to P-D-680, Type II, solvent can be very ______________ to different parts of the ______________.

2. If the solvent comes in contact with the eyes, it will cause ______________, ______________ and ______________.

3. Repeated skin contact will cause ______________, ______________ and ______________.

Trichloroethylene

(Tri-chlo-roe-thy-lene), trichloroethylene is another type of solvent you might use as an environmental systems mechanic. It is used to clean oxygen parts, degrease bearings, clean motor gear trains, etc. Do not try to clean electrical wiring with trichloroethylene as the wire insulation will deteriorate.

WARNING

This is a very dangerous solvent that could be hazardous to your health if not properly used. Adequate ventilation must be provided and protective clothing worn when working with this solvent.

The reason this solvent is so harmful is because it will attack the *respiratory system, heart, liver, kidneys, central nervous system, and skin. It can get into your system by inhalation, absorption through the skin, and eye contact.

Overexposure to trichloroethylene will cause irritation of the nose and throat, irregular heart beat, *vertigo, tremors, nausea, sleepiness, and it is a suspected cancer-causing agent. Repeated contact with the skin will cause dermatitis.

All these effects can be prevented by using protective clothing, eye goggles, having proper ventilation, and washing with soap immediately after getting it on your skin.

//////////

NO RESPONSE REQUIRED

Solvent Emulsion Cleaners

This type of cleaner removes a soil by *emulsifying the oil constituents of the soil and holding it in *suspension in water.

//////////

NO RESPONSE REQUIRED

Special Cleaners

These are cleaners such as steam and carbon removers. They are used to degrease certain types of equipment.

//////////

NO RESPONSE REQUIRED

Frame 12

Now we will discuss the second half of this programmed text, which is lubricants/oils.

Lubrication of most parts in a system is done during scheduled inspections or when a new part is installed. ALWAYS CONSULT THE APPROPRIATE TECHNICAL ORDER FOR SERVICING INSTRUCTIONS AND TYPE OF LUBRICANT TO USE. Lubricants used in one part may be different in another kind of aircraft than the same part used in another. Periodic oil change intervals must be complied with to insure proper lubrication, thus, prolonging the life of the part. Dirty oil contributes to an early failure.

The shop chief must insure that newly received oil or lubricants for cooling turbines, air turbine motors, alternator drives, and starters are of the correct specification. You must remember to CHECK THE TO for the proper lubricant.

//////////

Answer the following statements as true (T) or false (F).

1. Lubrication of most system parts is done during scheduled inspections. ______

2. Dirty oil contributes to an early failure. ______

Frame 13

The first type of lubricant we will discuss is specification MIL-L-7645. Note: The MIL-L- in this and other specification numbers indicates a MILitary Lubricant. MIL-L-7645 is a semi-solid, noncorrosive, mild pressure lubricant. It is used for gears, screws and threaded parts. MIL-L-7645 is not an extreme pressure or *hypoid lubricant.

//////////

Answer each of the statements as true (T) or false (F).

1. MIL-L-7645 is a noncorrosive lubricant. ______

2. MIL-L-7645 is a single-grade aircraft turbine lubricating oil. ______

Specification MIL-G-4343

Specification MIL-G-4343 is a grease used to lubricate between rudder and metal parts on pneumatic systems. It may be used for pneumatic systems, pressurized cabin bulkhead grommets and other mechanisms.

//////////

Answer each of the statements as true (T) or false (F).

1. MIL-G-4343 may be used for lubricating grommets between pressurized cabin bulkheads. ______

2. MIL-G-4343 is a single-grade of aircraft turbine grease. ______

Specification MIL-L-007808F

Specification MIL-L-007808F lubricating oil is one of the most used. It lists oils of a single grade. These oils are used in turbine engines and helicopter transmissions.

//////////

Answer each of the statements as true (T) or false (F).

1. MIL-L-007808F lubricating oil covers a single grade of aircraft turbine lubricating oil. ______

2. MIL-L-007808F lubricating oil is intended for aircraft instruments. ______

Specification MIL-L-6085

Specification MIL-L-6085 is another one of the most used lubricating oils. It lists oils that are used in aircraft instruments, electronic instruments, electronic equipment, or where a low evaporation oil is required for both high and low temperature operations. These oils can be used where *oxidation and corrosion resistance is desirable.

//////////

Answer each of the statements as true (T) or false (F).

1. MIL-L-6085 is considered to be a low evaporating lubricant.

____

2. MIL-L-6085 lubricating oil may not be used where high or low temperatures are applicable. ______

3. MIL-L-6085 lubricating oil is not a corrosion resistance oil.

____

Frame 17

Keep in mind, these are not all the lubricants/oils and greases that are used in the Air Force. When you need any lubricant or grease for repair jobs, REFER TO A TECHNICAL ORDER for correct specification.

//////////

NO RESPONSE REQUIRED

GLOSSARY OF TERMS

ALKALINE	
ASPHYXIATION	To cause to die or lose consciousness by blocking normal breathing
CB (chloro-bro-mo-me-thane)	A fire extinguishing agent which produces a gas dense enough to displace most of the oxygen in the area
CONSTITUENT	Properties (parts) of a component or a thing
DEFATTING	Affects all the fat tissue in the body, reducing fat tissue to a dangerous level
DERMATITIS	Inflammation of the skin
DB (di-bro-mo-difluoro-me-thane)	A fire extinguishing agent, which displaces most of the oxygen in the area. The vapors are more toxic (poisonous) than CB.
EMULSIFYING	Suspension of very fine particles of a liquid in another liquid, separating parts of a substance in a liquid
HYPOID	
OXIDATION	
PNEUMONITIS	
RESPIRATORY	Pertaining to breathing
SCALE	A hard or brittle coating
SUSPENSION	The particles of a substance are mixed with a fluid but are not dissolved
TREMORS	
TRICHLOROETHYLENE	
VERTIGO	Disordered condition in which a person feels that his/her surroundings are whirling about.(turning/dizzy).
VISCOUS	Sticky, thick, adhesive

ANSWERS TO FRAME QUESTIONS

Frame 1: No Response

Frame 2: 1. Type and amount of soil
2. base material composition and surface condition
3. degree of cleanliness required

Frame 3: 1. a. oily soils
b. semi-solid soils
c. soils containing solids
2. F

Frame 4: 1. F
2. F

Frame 5: 1. difficult to remove
2. increase, removal

Frame 6: T

Frame 7: 1. T
2. F

Frame 8: 1. harmful, body
2. irritation, redness, tearing
3. irritation, defatting, dermatitis

Frame 9: No Response

Frame 10: No Response

Frame 11: No Response

Frame 12: 1. F
2. T

Frame 13: 1. T
2. F

Frame 14: 1. T
2. F

Frame 15: 1. T
2. F

Frame 16: 1. T
2. F
3. F

Frame 17: No Response

SERVICE TEST
PROGRAMMED TEXT
C3ABR42331-PT-305B

Technical Training

Aircraft Environmental Systems Mechanic

METHODS OF CONTROLLING CORROSION

10 November 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

OBJECTIVE

Identify methods used to slow corrosion on bleed air ducting, answering a minimum of four of five questions correctly.

Note: If there is an asterisk (*) next to a word, you are to go to the GLOSSARY OF TERMS in the back of this PT. It will help you in understanding some of the words used in this PT.

INSTRUCTIONS

Compare your answers with the correct answers given at the back of the programmed text. If you find you are incorrect, reread the frame to get the correct information.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTC/TTGU-P - 250; DAV - 1

Frame 1

Corrosion control is of major importance in all aircraft and missile maintenance. Corrosion can weaken structural members enough to destroy system reliability. This weakening can result in a major repair or replacement of the entire system. Such repairs and replacements are costly and time consuming. Much of this waste is a result of a lack of knowledge on the subject of corrosion control. But before we can understand methods of controlling corrosion, we must learn what corrosion is and some of the types of corrosion.

Fee! Fi! Fo! Fum!
PLEASE PASS THE USAF'S
ALUMINUM!

THE CORROSION MENACE

No Response Required

Frame 2

Corrosion is the deterioration of a metal as it reacts to its environment in an attempt to return to its natural state. It is visible in many forms and is typed in different ways. For descriptive purposes, we will discuss the types under their commonly accepted titles: Uniform etch, pitting, intergranular, galvanic, stress, fatigue and filiform.

Answer each of the statements as true (T) or false (F).

____ 1. Corrosion is not visible in metals.

____ 2. Corrosion is the deterioration of a metal as it reacts to its environment.

____ 3. Metal corrodes because it attempts to return to its natural state.

Uniform Etch Corrosion:

Uniform Etch* corrosion results from a direct chemical attack on a metal surface. These chemicals may be salts deposited from coastal operations, urine spray, battery acid spillage, or gases absorbed from the environment. On a polished surface, uniform etch is first seen as a general dulling of the surface. If this corrosion is allowed to continue, the surface becomes rough and sometimes frosted in appearance.

Uniform Etch may be treated by both mechanical and chemical methods.*

Warning

> Before treating any type of corrosion, consult the appropriate technical order.

Fill in the blanks with the correct answer.

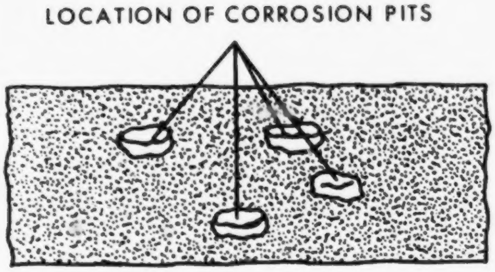
1. On a polished surface, uniform etch is first seen as a ______________ ______________ of the ______________.

2. If this corrosion is allowed to continue, the ______________ becomes ______________ and ______________ ______________ in appearance.

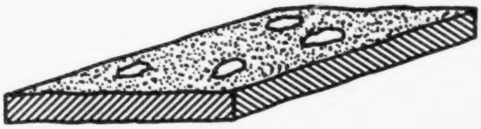
*See Glossary of Terms in back of book.

Frame 4

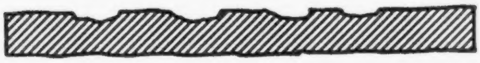
Pitting Corrosion:



VIEW LOOKING DOWN



VIEW IN TRUE PERSPECTIVE



CROSS-SECTION VIEW

CI 83-5630
0-10i2

Figure 1. Pitting Corrosion.

Though some factors influence the uniform destruction of metal surfaces, other factors influence a localized attack commonly called pitting corrosion. See figure 1.

Pitting is the most common effect of corrosion on aluminum and magnesium alloy parts. It is first noticed as a white or gray powdery deposit, similar to dust, which blotches the metal surface. When the deposit is cleaned away, tiny pits or holes can be seen in the surface. Pitting corrosion may also occur in other types of metal alloys, such as iron. The only difference is that iron produces red and brown powdery deposits.

Pitting corrosion may be treated by applying a chromic acid solution.

Fill in the blanks with the correct response.

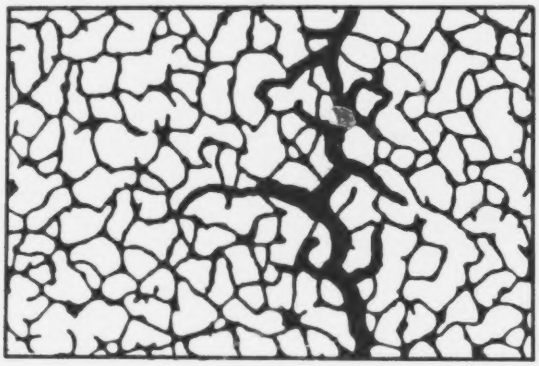
1. A pitting corrosion of aluminum or magnesium is first noticed as ______________ or ______________ powdery deposits that blotches the ______________ ______________.

2. The pitting of iron produces ______________ and ______________ deposits.

Frame 5

Intergranular Corrosion:

Intergranular* corrosion is a selective attack along the grain boundaries of a metal. A highly magnified cross section of an alloyed metal shows the granular structure of that metal. This structure consists of quantities of individual grains. Each of these tiny grains has a clearly defined boundary that differs chemically from the metal within the grain center.



CI 83-5631
0-10i2

Figure 2. Intergranular Corrosion.

Intergranular corrosion, shown in figure 2, is caused by the precipitation of alloying elements out of the grain and into or near the grain boundary. The grain, losing its alloying elements, becomes anodic* to the surrounding grains. In the presence of an electrolyte*, current flows and rapid intergranular corrosion occurs. In other words, intergranular corrosion will cause the metal structure to break down and crack. It can be treated by the mechanical method.*

*See Glossary of Terms

Answer each of the statements as true (T) or false (F).

____ 1. Intergranular corrosion is a selective attack along the grain boundaries of a metal.

____ 2. The grain, gaining its alloying elements, becomes anodic to the surrounding grains.

Galvanic Corrosion:

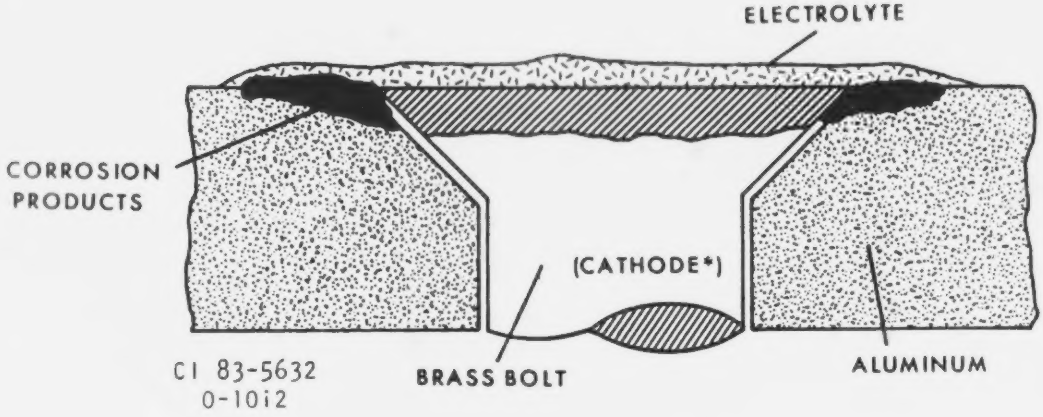


Figure 3. Galvanic Corrosion.

Galvanic* corrosion occurs when two dissimilar metals are in contact, and an external circuit is provided by the presence of moisture (electrolyte). It is usually recognized by the presence of a buildup of corrosion between the metals. A prime example is a brass screw or bolt attached to an aluminum panel shown in figure 3.

When practical, use rivets, bolts, and nuts that are of the same material as the main structure. If it is not possible to use the same material, galvanic corrosion can be slowed by using sacrifical washers, insulating tape, or sealant to isolate the galvanic contact.

*See Glossary of Terms

Answer each of the statements as true (T) or false (F)

____ 1. Galvanic corrosion occurs when two similar metals are coupled together in the presence of an electrolyte.

____ 2. When practical, use rivets, bolts and nuts that are different to the main structure.

Frame 7

Stress Corrosion:

Stress corrosion is produced by the simultaneous effect of tensile stress and a corrosive environment. If a part in a stressed condition is in contact with an electrolyte, severe corrosion can occur, because the stressed area of a part has been found to be anodic to an unstressed area.

Generally, stresses in the neighborhood of the yield strength of the metal are needed to cause stress corrosion cracking. When a crack appears, it usually runs parallel to the granular structure of the metal.

Stress corrosion may be prevented by removing the corrosive environment. This may be done by applying protective coatings, using corrosion inhibitors or controlling the environment.

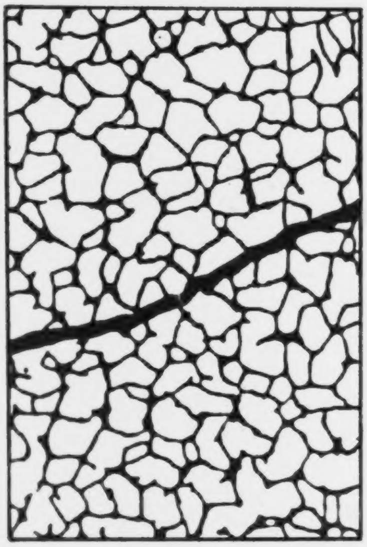
Fill in the blanks with the correct response.

1. Stress corrosion is produced by the _______________ effects of _______________ stress and a _______________ environment.

2. When a crack appears, it usually runs _______________ to the _______________ _______________ of the _______________.

Fatigue Corrosion:

Fatigue corrosion is a special form of stress corrosion, produced by the effects of an alternating cyclic stress and a corrosive environment. Fatigue corrosion failure generally occurs in two stages. During the first stage, the combined action of corrosion and the cyclic action concentrates the stresses in the vicinity of any pits.



CI 83-5633
0-10i2

Figure 4. Fatigue Corrosion.

In the second stage, the concentration of stresses causes cracks to develop in the base of the pits. The cracks develop rapidly and gradually penetrate the section until a fracture occurs, as shown in figure 4. Fatigue corrosion cracks are different from stress corrosion cracks, because they usually run across the granular structure of the metal.

Generally, fatigue corrosion cracking occurs at a point far below the normal design fatigue limits of the metal. This happens even though there is little evidence of actual corrosion. For this reason, metals subjected to alternating cyclic stresses must be protected, even in mildly corrosive environments.

Answer each of the statements as true (T) or false (F).

____ 1. Fatigue corrosion is a special form of tensile corrosion.

____ 2. Fatigue corrosion failure generally occurs in three cycles.

____ 3. Fatigue corrosion cracks are different from stress corrosion cracks.

Frame 9

Filiform* Corrosion

Occasionally, metals with organic coatings undergo a type of corrosion that results in numerous threadlike filaments of corrosion products under the coating. This type of corrosion is caused by the diffusion* of oxygen and water through the coating and is considered a typical type of oxygen concentration cell.* You can control or curtail* filiform corrosion by storing aircraft or equipment in a low himidity environment and by using coatings with a high resistance to diffusion by water.

Now that we have talked about some of the different types of corrosion, let's begin to talk about methods of controlling corrosion.

Answer each of the statements as true (T) or false (F).

____ 1. Filiform corrosion is caused by the diffusion of oxygen and water through the coating.

____ 2. Filiform corrosion is a typical type of hydrogen concentration cell.

*See Glossary of Terms

Frame 10

Corrosion Control Methods

By definition, corrosion control is the effort to minimize the development of, and damage from, corrosion by properly conducting identification, isolation, and other corrective actions on a timely basis. This means you are to inspect, defect, and promptly perform required maintenance procedures to eliminate the cause of corrosion and treat the metal surface to prevent further corrosion.

No Response Required

Frame 11

Some of the methods used in decreasing the problem of corrosion damage include frequent inspections, determining the causes of corrosion, and protecting the metal from further attack.

We have already discussed how to control some of the types of corrosion, but there are several other things that can be done to control corrosion. The metal can be painted, waxed, oiled, or coated with a metal that corrodes slowly. The process used most is to coat the metal with a metal that corrodes slowly. This process is known as anodizing, aluminum cladding, chrome plating, or copper plating to name a few.

Another way of controlling corrosion is to perform frequent inspections to insure cleanliness and to check for entrapped moisture, the condition of protective coating, and evidence of corrosion. Also, if you are going to ship equipment and components, be sure to use protective packing and packaging to protect the parts from corrosion.

Early detection and prompt action are essential to controlling corrosion.

No Response Required

Glossary of Terms:

1. Anode = any positively charged electrode, as of an electrolytic cell, storage battery, or electron tube.

2. Cathode = any negatively charged electrode, as of an electrolytic cell, storage battery, or electron tube.

3. Chemical Method of Removing Corrosion = heavy corrosion being removed by using different types of chemical substances.

Warning

Before using any chemicals, consult the appropriate technical order.

4. Curtail = to cut short; cut off a part of; abridge; reduce.

5. Diffusion = an intermingling of modules, ions, etc., resulting from random thermal agitation, as in the dispersion of a vapor in air; scattering.

6. Electrolyte = moisture or other contamination.

7. Filiform = threadlike; filamentous.

8. Galvanic = pertaining to or produced by galvanism; producing or caused by an electric current.

9. Galvanism = electricity, esp. as produced by chemical action.

10. Intergranular = Two words: inter meaning between, together, among, during and granular meaning made of grains.

11. Mechanical Method of Removing Corrosion = removing corrosion by hand scraping with a suitable carbide tipped scraper or fine fluited rotary file.

12. Organic = a class of compounds derived from plants or animals.

13. Oxygen Concentration Cell = occurs when a solution contains varying amounts of dissolved oxygen. A crevice, sharp corner, or lap joint may prevent the oxygen from dissolving uniformly throughout the electrolyte.

14. Uniform Etch = Two words: uniform meaning identical without variation in detail, and etch meaning to cut, bite or corrode with an acid or the like.

Answers:

Frame 1

No Response Required

Frame 2

1. F
2. T
3. T

Frame 3

1. general dulling surface
2. surface rough and sometimes frosted

Frame 4

1. white or gray, metal surface
2. red and brown

Frame 5

1. T
2. F

Frame 6

1. F
2. F

Frame 7

1. simultaneous, tensile stress and a corrosive
2. parallel, granular structure of the metal

Frame 8

1. F
2. F
3. T

Frame 9

1. T
2. F

Frame 10

No Response Required

Frame 11

No Response Required

PROGRAMMED TEXT
3ABR42331-PT-306

Technical Training

Aircraft Environmental Systems Mechanic

AIR TURBINE MOTOR (ATM)

3 February 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: 10.0

OBJECTIVE

~~Identify~~ Specify general principles pertaining to the operation of an air turbine motor with 80% accuracy.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After each frame you are asked to respond by selecting one or more correct statements or by entering "T" (true) or "F" (false) in the appropriate blank. After you have made your response, compare your answer with the correct answer that is given on the next even numbered page following each frame. If your response is incorrect, restudy the frame to get the information correctly in your mind. DO NOT MARK IN THIS TEXT.

INTRODUCTION

While working as an Environmental System Specialist, you will be required to maintain air turbine motor systems installed on various types of aircraft. This text describes a typical air turbine motor. It also describes what an air turbine motor is used for and the principles of operation.

Supersedes 3ABR42331-PT-316, 28 July 1978.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; TTVSA - 1

The Air Turbine Motor (ATM), is a motor driven by air pressure directed against the curved vanes of a wheel. This wheel is connected to a series of gears which are used to drive any of the following components: alternators, generators, and/or hydraulic pumps. (Refer to figure 1 below.)

The primary purpose of the air turbine motor is for an emergency source of electrical power or hydraulic pressure during in-flight emergencies. It may also be used for a source of auxiliary electrical power or hydraulic pressure during ground operation. Not all aircraft are equipped with an air turbine motor.

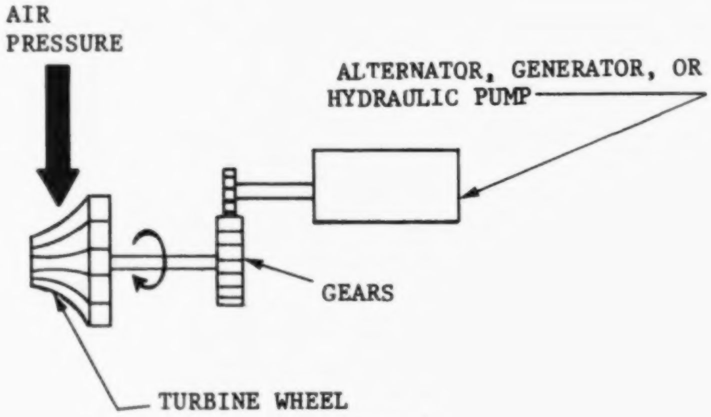


Figure 1.

Answer the following statements TRUE or FALSE.

_____1. The air turbine motor is driven by an electrical motor.

_____2. The primary purpose of the air turbine motor is for an emergency source of electrical power and/or hydraulic pressure.

_____3. All aircraft are equipped with an air turbine motor.

Correct Responses to Frame 1: __F__ 1. __T__ 2. __F__ 3.

Note: From this time on, the text will refer to the air turbine motor as ATM.

Frame 2

The sources of air that are used to drive the ATM are as follows:

1. Engine Bleed Air (EBA) for ground or flight operation.

2. Gas Turbine Compressor (GTC) for ground operation on some aircraft.

3. Ground Air Cart (MA-1A) for ground operation ONLY.

Answer the following statements TRUE or FALSE.

_____1. The MA-1A is used to drive the ATM during flight operation.

_____2. The GTC provides air to drive the ATM during ground operation on some aircraft.

_____3. EBA can be used to drive the ATM for both ground and flight operation.

_____4. The abbreviation for Air Turbine Motor is ATM.

Frame 3

In order to understand the complete operation of the ATM, you must understand the operation of the basic parts making up the ATM. The basic parts of the ATM consists of; a turbine wheel, gear box assembly, and a speed control system. Before we discuss the operation of the ATM, we will first discuss the basic parts and their operation.

NO RESPONSE REQUIRED

Let us first discuss the turbine wheel. By now you should be familiar with the principles of a turbine wheel. If you remember from previous blocks of instruction, a turbine wheel is a curved vane wheel. The turbine wheel will rotate when a pressurized air flow is directed on it. The turbine wheel of the ATM is connected to a series of gears within the ATM gear box (the gear box will be discussed in a later frame).

The turbine volute (turbine wheel housing) encloses the turbine wheel. (Refer to figure 2.) A pressurized air source is applied to the turbine volute inlet. The volute directs the air flow to the turbine wheel vanes. The turbine wheel will then rotate, turning the gears inside the ATM gear box.

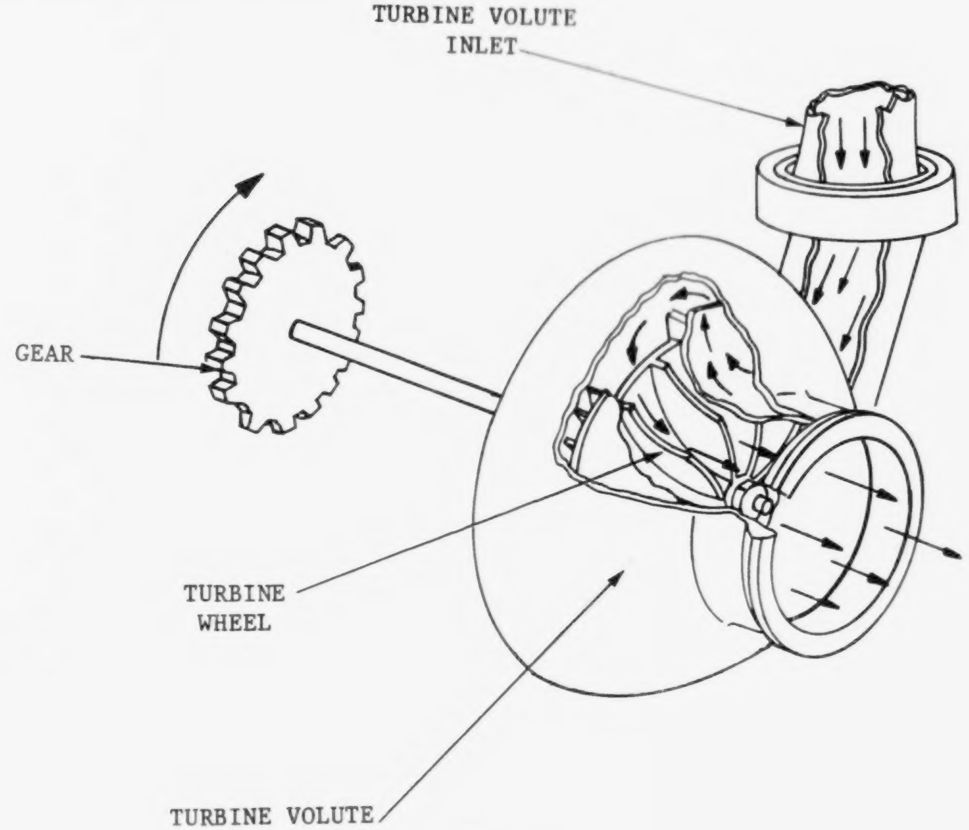


Figure 2.

Answer the following statements TRUE or FALSE.

_____1. The turbine volute houses the turbine wheel.

_____2. The turbine wheel drives a series of gears in the ATM gear box.

Correct Responses to Frame 2: F 1. T 2. T 3. T 4.

Correct Response to Frame 3: None required.

Correct Responses to Frame 4: T 1. T 2.

Frame 5

The ATM gear box houses a series of gears (gear train). This gear train is a reduction type. There are two output drive pads that are driven by the gear train. (Refer to figure 3.) The upper output drive pad is used to drive an alternator or generator (depending on the type of aircraft the ATM is installed on). The lower output pad is used to drive a hydraulic pump. The turbine wheel turns at a controlled speed of 43,000 RPM. The speed control system (which will be discussed in a later frame) controls the turbine wheel speed. The upper output drive pad will drive an alternator or generator at a speed of 6,000 RPM. The lower output pad will drive a hydraulic pump at a speed of 3,500 RPM. The two output drive pad speeds are reduced by a reduction type gear train.

Answer the following statements TRUE or FALSE.

_____1. The alternator or generator is driven at 6,000 RPM.

_____2. The hydraulic pump is driven at 3,500 RPM.

_____3. The turbine wheel is turning at 43,000 RPM.

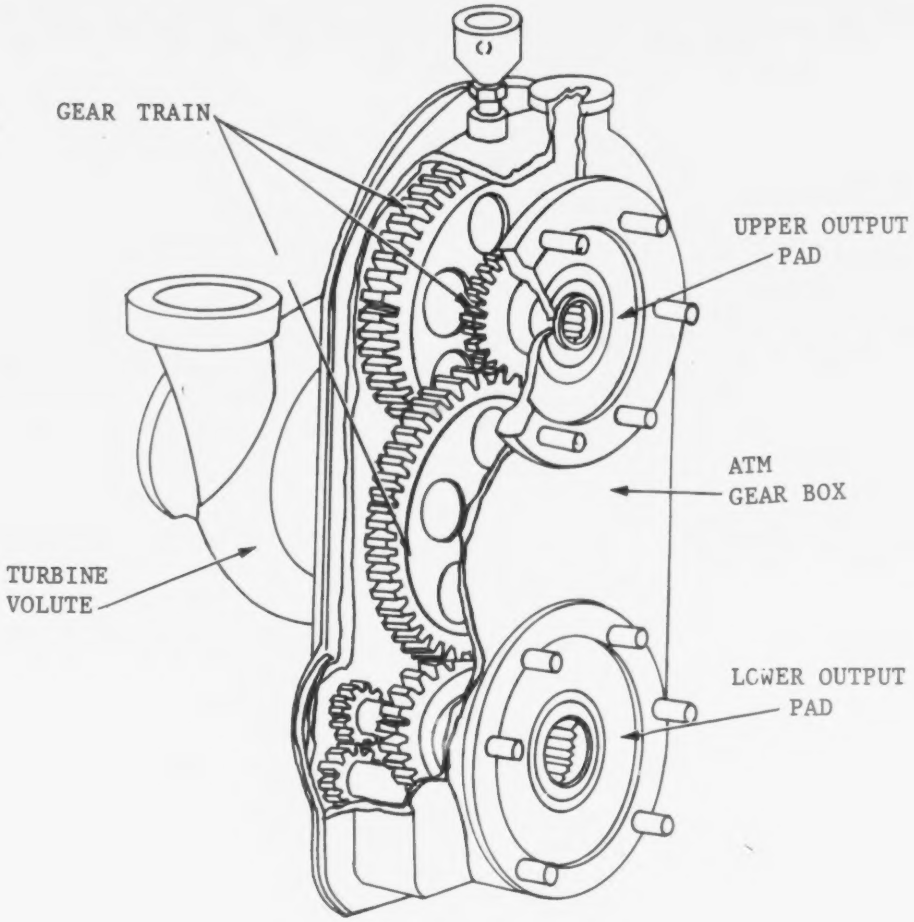

GEAR TRAIN
UPPER OUTPUT PAD
ATM GEAR BOX
TURBINE VOLUTE
LOWER OUTPUT PAD

Figure 3.

Correct Responses to Frame 5: _T_ 1. _T_ 2. _T_ 3.

Frame 6

The ATM has an internal oil supply. Oil is taken from the bottom of the ATM gear box by an oil pump. The oil is forced through an oil filter and then through an oil cooler. The oil cooler works on the same principles as a radiator in a car. The oil passes through tubing which cooling air flows across. The cooling air is forced in through the bottom of the oil cooler, over the oil cooling lines, and then out the oil cooler air outlet. (Refer to figure 4A.)

Note: Cooling air is supplied by ram air during flight or an ATM cooling fan during ground operation.

The cooled oil is then directed to the ATM gears and bearings inside the gear box. The oil then falls back down to the bottom of the ATM gear box and is recirculated again. The ATM has a filler cap and an oil level sight gage for servicing the ATM with oil. The ATM must always be properly serviced with the proper amount and type of oil to prevent internal damage. The ATM is serviced with Military Specification MIL-L-23699 type oil when the oil level reached the ADD mark on the lower sight gage. (Refer to figure 4.) The oil is poured in the ATM filler port until the oil level reaches the FULL mark on the upper sight gage.

Caution: Never overfill the ATM with oil.

Answer the following statements TRUE or FALSE.

_____1. Oil for the ATM is taken from the engine oil supply.

_____2. Oil is directed through the ATM by an oil pump.

_____3. Military Specification MIL-L-6808 is used in the ATM.

_____4. An oil cooler is used to cool the ATM oil.

_____5. When the ATM oil level is below the FULL mark but not to the ADD mark, the ATM must be serviced with oil.

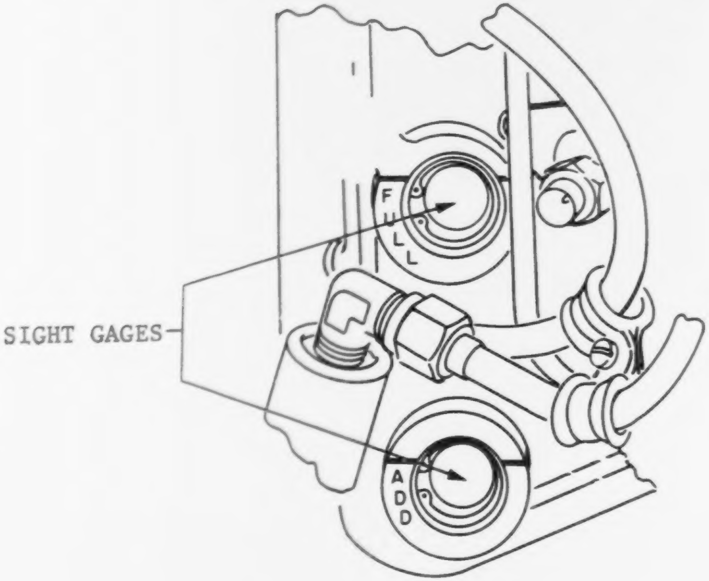

SIGHT GAGES
FULL
ADD

Figure 4.

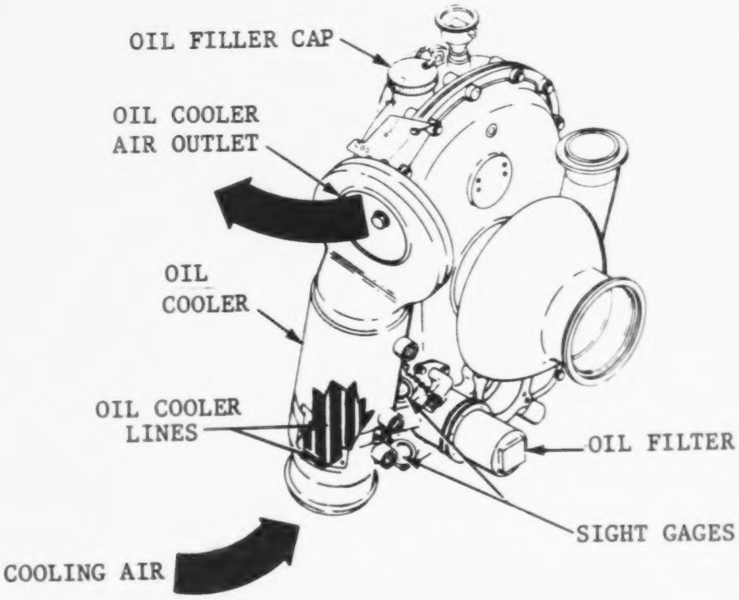

OIL FILLER CAP
OIL COOLER AIR OUTLET
OIL COOLER
OIL COOLER LINES
OIL FILTER
SIGHT GAGES
COOLING AIR

Figure 4A.

Correct Responses to Frame 6: F 1. T 2. F 3. T 4. F 5.

Frame 7

The ATM is a pneumatically operated motor. This means it is operated by air pressure. Air pressure, from the aircraft bleed air system, enters the ATM at the AIR INLET. (Refer to figure 5.) The air entering the ATM is controlled by a shutoff valve and a modulating valve. Some of the air entering the ATM air inlet is tapped off before the shutoff valve butterfly. This air is then directed, by metal tubing, to the shutoff valve actuator opening diaphragm, solenoid valve, and overspeed trip assembly. Some air is also tapped off between the shutoff valve and the modulating valve butterfly. This air goes through the oil cooler, moisture separator, air filter, and pressure regulator. The air is then directed to the compensating diaphragm of the modulating valve actuator (mod valve actuator). The air is also directed through the speed controller to the actuating diaphragm of the mod valve actuator. When the shutoff valve and mod valve butterflies open, the bleed air is directed through the turbine volute. The turbine volute directs the air to the turbine wheel, then out the turbine exhaust.

Answer the following statements TRUE or FALSE.

_____1. The ATM is electrically operated.

_____2. Air from the speed controller goes to the actuating diaphragm of the modulating valve.

_____3. The air that goes to the modulating valve actuator, goes through the oil cooler first.

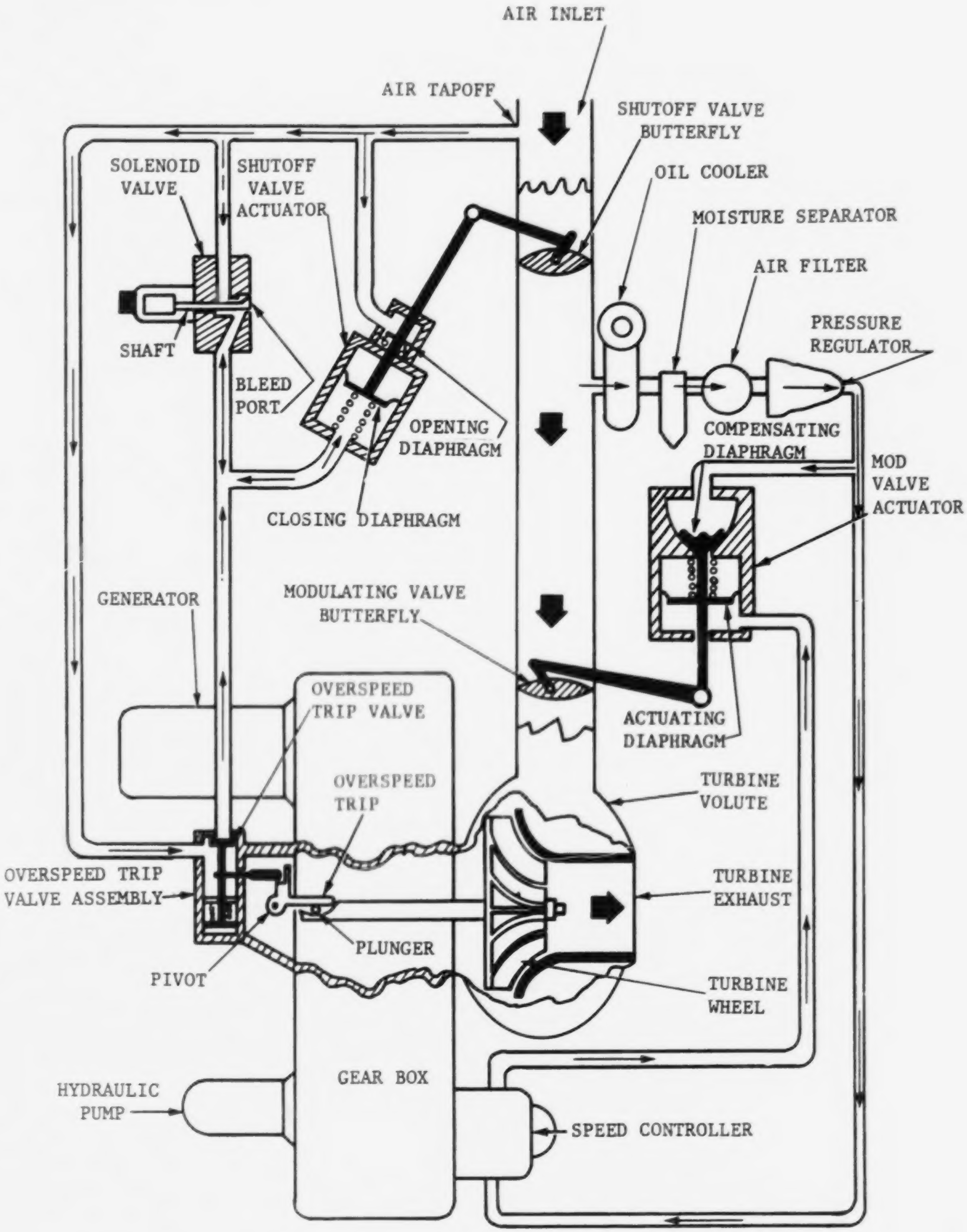

AIR INLET
AIR TAPOFF
SHUTOFF VALVE BUTTERFLY
OIL COOLER
MOISTURE SEPARATOR
AIR FILTER
PRESSURE REGULATOR
SOLENOID VALVE
SHUTOFF VALVE ACTUATOR
SHAFT
BLEED PORT
OPENING DIAPHRAGM
CLOSING DIAPHRAGM
COMPENSATING DIAPHRAGM
MOD VALVE ACTUATOR
GENERATOR
MODULATING VALVE BUTTERFLY
OVERSPEED TRIP VALVE
OVERSPEED TRIP
ACTUATING DIAPHRAGM
TURBINE VOLUTE
OVERSPEED TRIP VALVE ASSEMBLY
TURBINE EXHAUST
PLUNGER
PIVOT
TURBINE WHEEL
GEAR BOX
HYDRAULIC PUMP
SPEED CONTROLLER

Figure 5.

Correct Responses to Frame 7: F 1. T 2. T 3.

Frame 8

At the beginning of this text, we stated that the ATM drives two output pads. The upper pad at 6,000 RPM and the lower pad at 3,500 RPM. This speed must be constant or the components attached to them will not work correctly. If there was no way to control the airflow that is directed to the turbine wheel, the turbine wheel speed would not be constant. This would directly affect the speed of the two output pads. For example: If the aircraft engines were running at idle speed, they would produce a lower pressure of bleed air. This would make the ATM turbine wheel turn at a low RPM. If the aircraft engines were then accelerated, the bleed air pressure would increase. This would make the ATM turbine wheel turn faster. Since the two output pads are driven through a series of gears, by the turbine wheel, the output pads speed would also vary. Therefore, we must have some way to control the amount of air pressure to the turbine wheel to control the output pad speed. In the following frames we will discuss how the ATM speed is controlled.

Answer the following statements TRUE or FALSE.

_____1. To control the output pad speed, the air pressure to the turbine wheel must be controlled.

_____2. Air pressure to the ATM inlet will always be at a constant pressure.

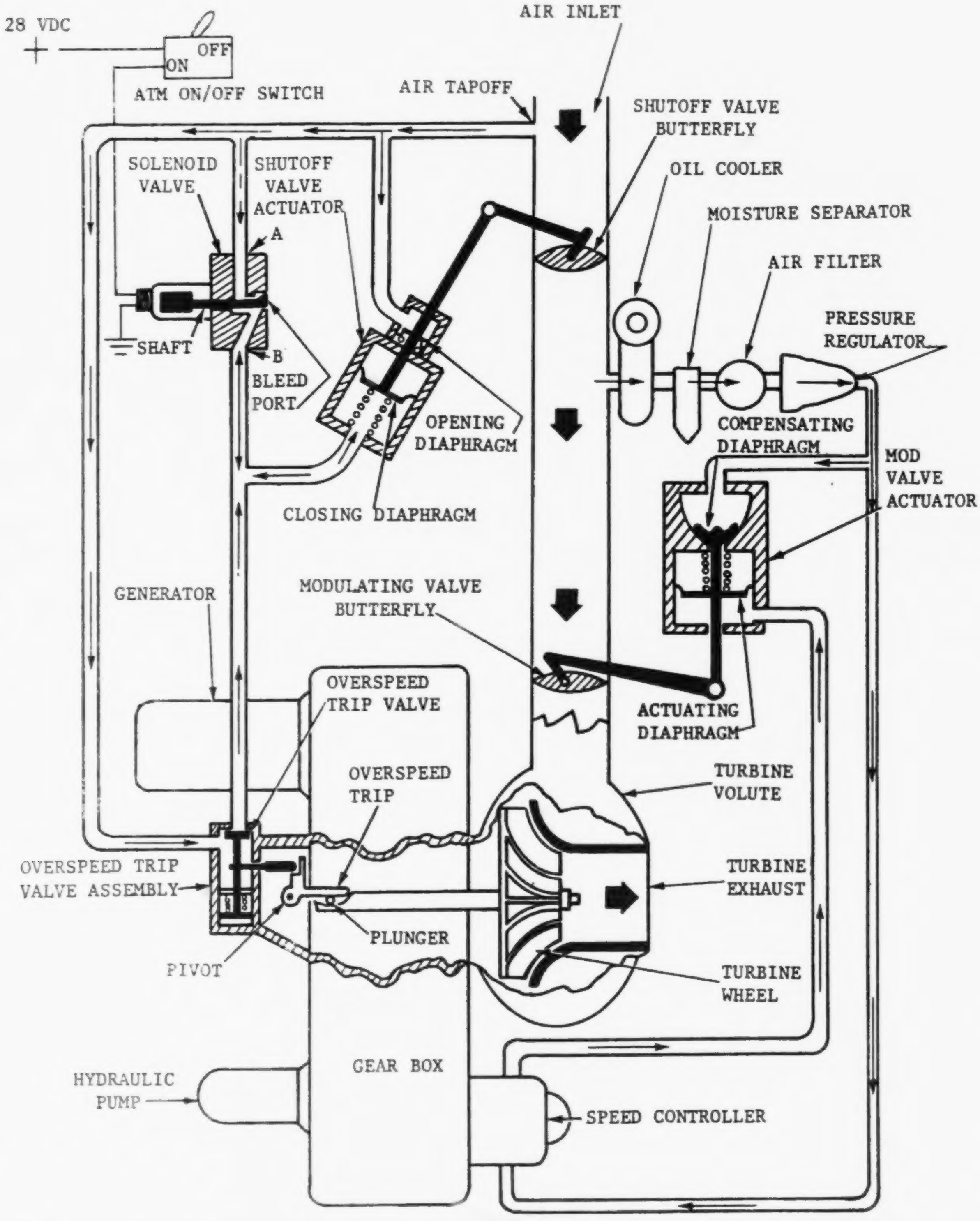

28 VDC
OFF
ON
ATM ON/OFF SWITCH
AIR INLET
AIR TAPOFF
SHUTOFF VALVE BUTTERFLY
OIL COOLER
MOISTURE SEPARATOR
AIR FILTER
PRESSURE REGULATOR
SOLENOID VALVE
SHUTOFF VALVE ACTUATOR
A
SHAFT
B
BLEED PORT
OPENING DIAPHRAGM
CLOSING DIAPHRAGM
COMPENSATING DIAPHRAGM
MOD VALVE ACTUATOR
GENERATOR
MODULATING VALVE BUTTERFLY
OVERSPEED TRIP VALVE
ACTUATING DIAPHRAGM
OVERSPEED TRIP
TURBINE VOLUTE
OVERSPEED TRIP VALVE ASSEMBLY
TURBINE EXHAUST
PLUNGER
PIVOT
TURBINE WHEEL
GEAR BOX
HYDRAULIC PUMP
SPEED CONTROLLER

Figure 6.

Correct Responses to Frame 8: T 1. F 2.

Frame 9

The first of our discussion will be those components that control the air pressure to the ATM turbine wheel. The air that enters the ATM is directly controlled by the ATM shutoff valve butterfly. (Refer to figure 6.) When an air source is applied to the ATM air inlet, the flow is stopped due to the ATM shutoff valve butterfly being closed. This valve is spring-loaded to the close position. Just above the ATM shutoff valve butterfly, air is directed (by an air tapoff) to the opening diaphragm of the ATM shutoff valve actuator and the solenoid valve. The solenoid valve is electrically controlled by the ATM ON/OFF switch. This switch is located in the crew compartment of the aircraft. When the ATM ON/OFF switch is placed to the OFF position, there will be no electrical power applied to the solenoid valve. Without electrical power, the solenoid is deenergized. This action closes off the bleed port and opens the inlet port (A) of the solenoid valve. Now, air entering port A, passes through the deenergized solenoid valve to port B. This air is then directed to the closing diaphragm of the ATM shutoff valve actuator. The air pressure, along with the spring tension on the closing diaphragm, will keep the shutoff valve butterfly closed. Since no air pressure can reach the ATM turbine wheel, the ATM will not operate.

Answer the following statements TRUE or FALSE.

_____1. The air pressure which is directed to the ATM shutoff valve actuator is tapped off below the ATM shutoff valve butterfly.

_____2. The ATM will not operate when the solenoid valve is deenergized.

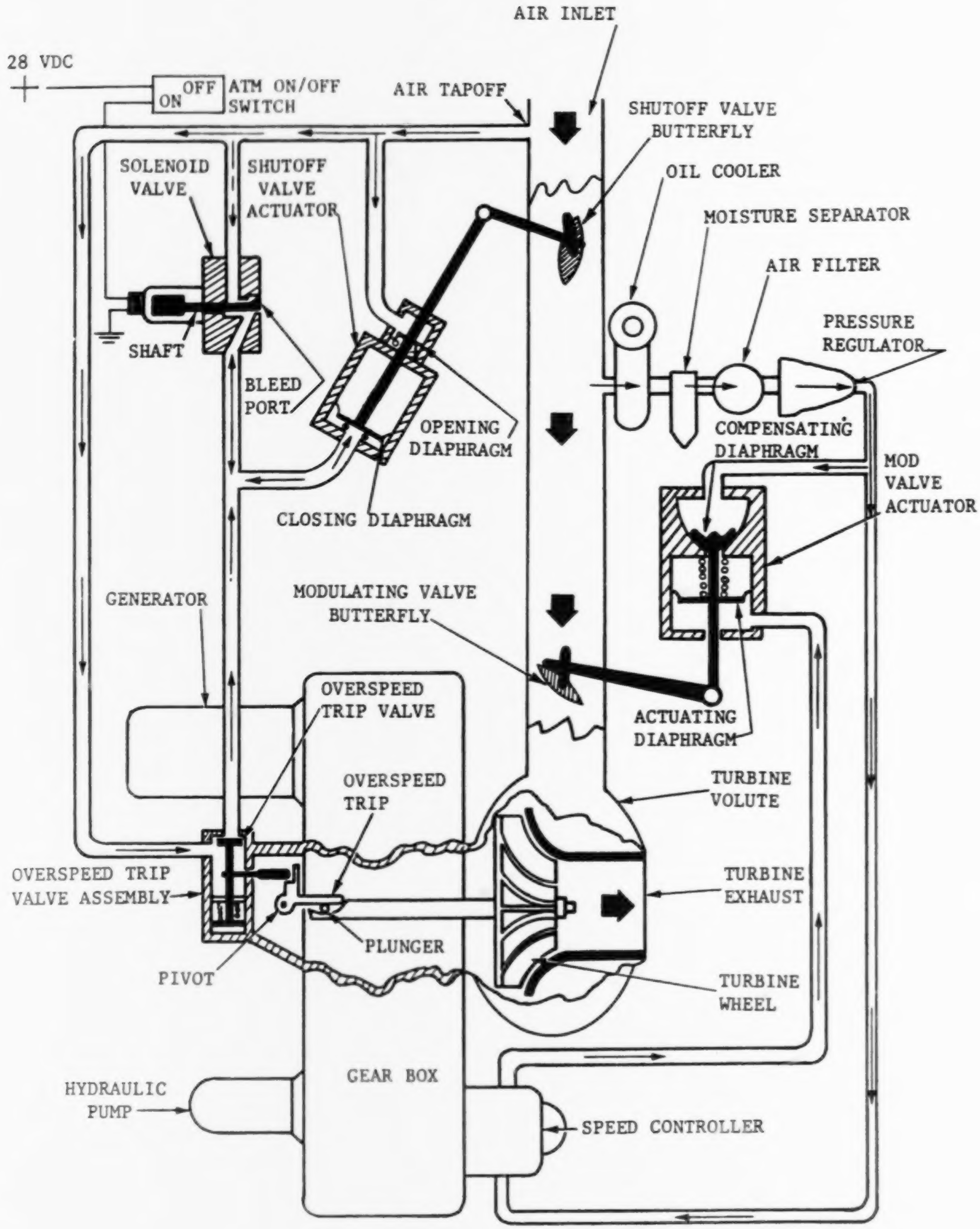

AIR INLET
28 VDC
ON OFF
ATM ON/OFF SWITCH
AIR TAPOFF
SHUTOFF VALVE BUTTERFLY
SOLENOID VALVE
SHUTOFF VALVE ACTUATOR
OIL COOLER
MOISTURE SEPARATOR
AIR FILTER
PRESSURE REGULATOR
SHAFT
BLEED PORT
OPENING DIAPHRAGM
COMPENSATING DIAPHRAGM
MOD VALVE ACTUATOR
CLOSING DIAPHRAGM
GENERATOR
MODULATING VALVE BUTTERFLY
OVERSPEED TRIP VALVE
ACTUATING DIAPHRAGM
OVERSPEED TRIP
TURBINE VOLUTE
OVERSPEED TRIP VALVE ASSEMBLY
TURBINE EXHAUST
PLUNGER
PIVOT
TURBINE WHEEL
GEAR BOX
HYDRAULIC PUMP
SPEED CONTROLLER

Figure 7.

Correct Responses to Frame 9: __F__1. __T__2.

Frame 10

When the ATM ON/OFF switch is in the ON position, (refer to figure 7) the solenoid valve energizes. Its shaft is drawn to the left, thereby opening its bleed port. This dumps the air pressure from the bottom of the closing diaphragm out through the open bleed port. Now, the force of the air on the top of the opening diaphragm will be enough to move the shutoff valve actuator downward. This, in turn, causes the butterfly valve to open and allow airflow to enter the ATM. Just below the shutoff valve butterfly, air pressure enters a tapoff and passes through the oil cooler. This oil cooler is a heat exchanger that serves two functions. It cools the lubricating oil from the gear box and it cools the air flow that passes through it. Ram air is the cooling agent. Once the air has been cooled, it passes through a moisture separator, air filter, and pressure regulator. The moisture separator eliminates any small particles of water from the air before it passes into the air filter. The air filter removes small particles of dust and dirt from the air. The pressure regulator regulates the air flow to a maximum 55 psig to the compensating diaphragm and speed controller.

Answer the following statements TRUE or FALSE.

_____1. The solenoid valve starts and stops the ATM.

_____2. The pressure regulator regulates pressure to the compensating diaphragm and speed controller to 55 psig.

_____3. The oil cooler cools air going to the solenoid and shutoff valves.

Frame 11

The speed controller (in figure 7) controls the air flow to the mod valve actuating diaphragm. The speed controller is driven by the turbine wheel through a series of gears. When the turbine wheel speed increases, the speed controller decreases the air flow applied to the mod valve actuating diaphragm. This, in turn, causes the modulating valve actuator to move the butterfly toward the close position. By closing the butterfly, the amount of air flow to the turbine wheel is decreased allowing the turbine wheel to slow down. As the turbine wheel decreases speed, the speed controller allows an increase in air pressure to the mod valve actuating diaphragm. The actuator will again cause the modulating valve butterfly to move toward the open position. This will increase air flow to the turbine wheel, thus, increasing its speed. In this way, the speed controller will control the turbine speed at 43,000 RPM.

Frame 11 (Cont'd)

Answer the following statements TRUE or FALSE.

_____1. The air pressure against the actuating diaphragm is controlled by the speed controller.

_____2. The force of the air pressure from the speed controller against the actuating diaphragm opens the modulating valve butterfly.

_____3. The purpose of the speed controller is to govern turbine wheel speed.

_____4. The modulating valve actuator operates the modulating valve butterfly.

Frame 12

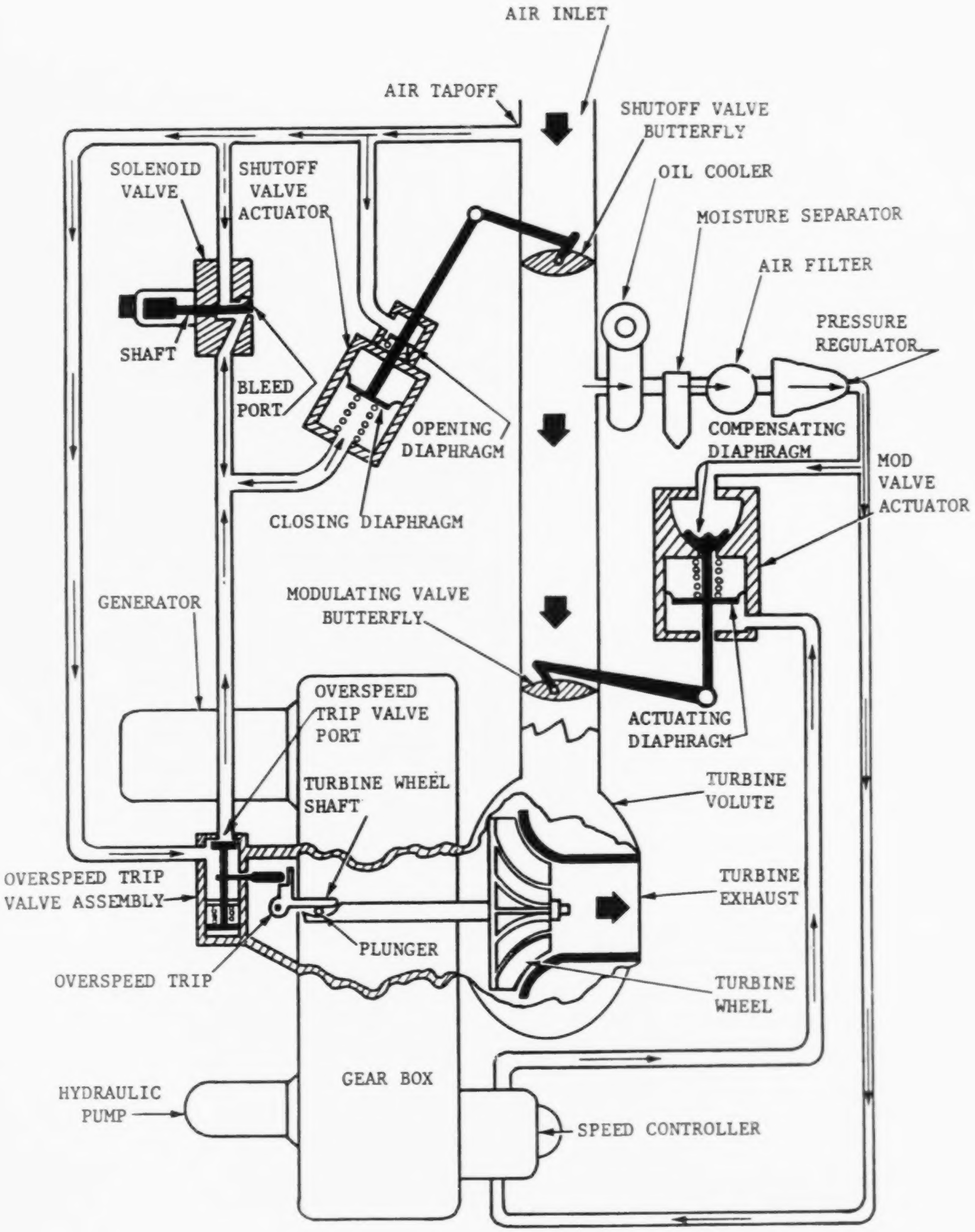
If the turbine sheel speed increases to a critical range of 52,000 to 56,000 RPM, centrifugal force causes a plunger on the turbine wheel shaft to move upward. (Refer to figure 8.) This causes the overspeed trip to rotate counterclockwise on its pivot. The overspeed trip forces the overspeed trip valve down and opens the overspeed trip valve port. Opening this port allows air pressure from the tapoff to be applied to the shutoff valve actuator closing diaphragm. When this air pressure is applied, the shutoff valve closes. This stops ATM operation, even though the solenoid valve small bleed port is still open. The overspeed trip valve must be reset after repairs are made.

Answer the following statements TRUE or FALSE.

_____1. Closing of the shutoff valve butterfly results in stopping ATM operation.

_____2. When turbine wheel speed reaches a speed between 52,000 to 56,000 RPM the overspeed trip valve port opens.

_____3. The overspeed trip plunger is operated by centrifugal force.


AIR INLET
AIR TAPOFF
SHUTOFF VALVE BUTTERFLY
OIL COOLER
MOISTURE SEPARATOR
AIR FILTER
PRESSURE REGULATOR
SOLENOID VALVE
SHUTOFF VALVE ACTUATOR
SHAFT
BLEED PORT
OPENING DIAPHRAGM
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COMPENSATING DIAPHRAGM
MOD VALVE ACTUATOR
GENERATOR
MODULATING VALVE BUTTERFLY
OVERSPEED TRIP VALVE PORT
ACTUATING DIAPHRAGM
TURBINE WHEEL SHAFT
TURBINE VOLUTE
OVERSPEED TRIP VALVE ASSEMBLY
TURBINE EXHAUST
PLUNGER
OVERSPEED TRIP
TURBINE WHEEL
GEAR BOX
HYDRAULIC PUMP
SPEED CONTROLLER

Figure 8.

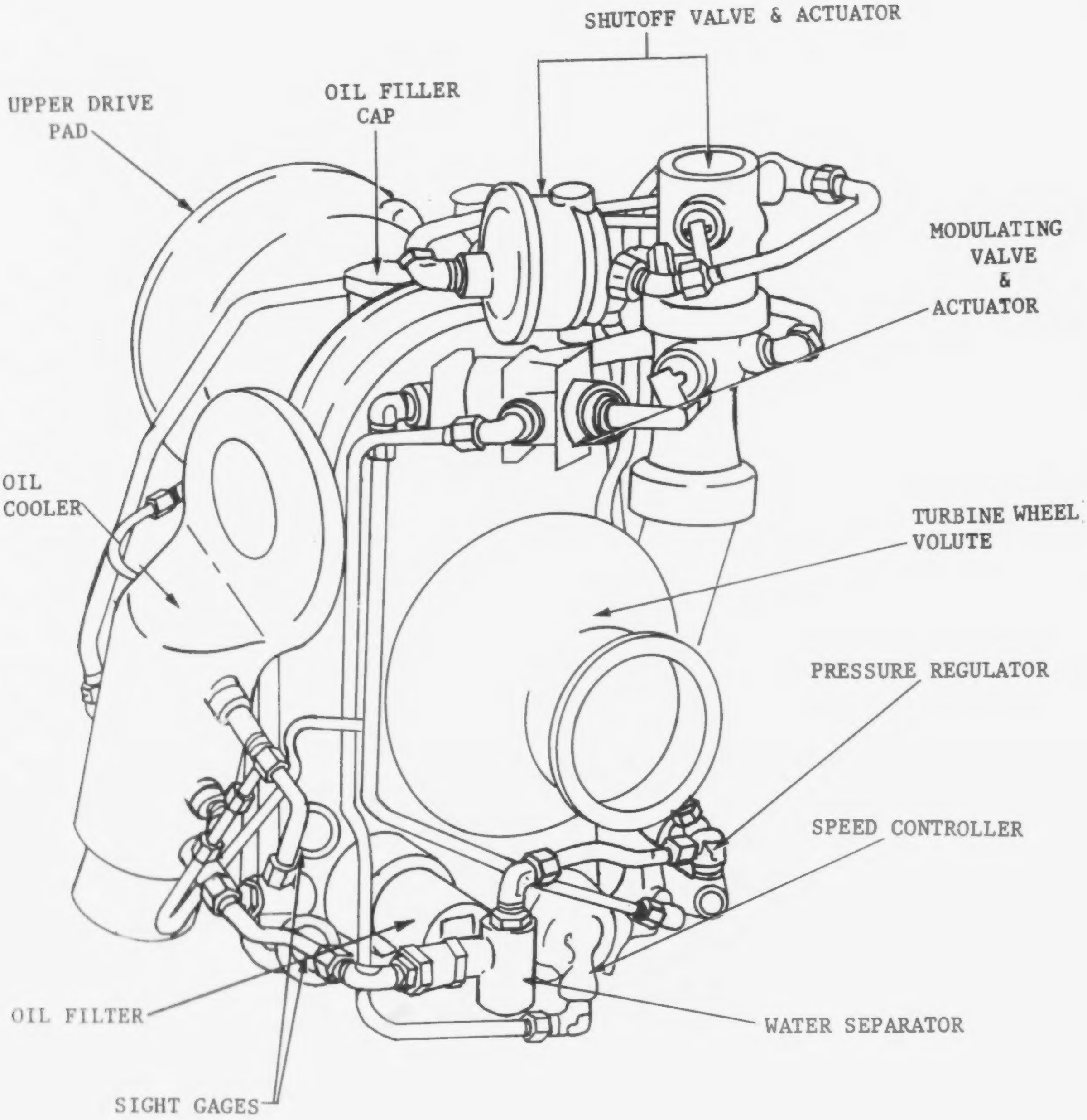
SHUTOFF VALVE & ACTUATOR
UPPER DRIVE PAD
OIL FILLER CAP
MODULATING VALVE & ACTUATOR
OIL COOLER
TURBINE WHEEL VOLUTE
PRESSURE REGULATOR
SPEED CONTROLLER
OIL FILTER
WATER SEPARATOR
SIGHT GAGES

Figure 9.

Correct Responses to Frame 10: T 1. T 2. F 3.
Correct Responses to Frame 11: T 1. T 2. T 3. T 4.
Correct Responses to Frame 12: T 1. T 2. T 3.

Frame 13

It is important that you become familiar with the procedures used in bench checking the components of the ATM. First the ATM must be removed from the aircraft and mounted on a test stand. Electrical power and bleed air are required, however, most checks are made with power and air off.

1. The solenoid valve - with 28VDC and air applied - can be checked by operating the on and off switch. In the on position the linkage should be fully retracted and with the switch in the off position the linkage should be fully extended.

2. The shutoff valve - power and air must be off for this check. The shutoff valve linkage must be free of binding and sticking and should move approximately 1" from the closed to open position. This check is made by moving the linkage by hand.

The opening diaphragm can be checked for leakage by moving the linkage to the open position by hand and by using a finger to cover the vent hole located on the bottom of the valve housing. If the diaphragm does not leak, the linkage will remain in the full open position as long as your finger is covering the vent hole. When your finger is removed from the vent hole, the linkage should return to the full closed position.

3. The overspeed trip valve - with power and air off - must be in the reset or closed position for the ATM to operate. Check by pressing in slowly on the overspeed reset button until the plunger is in as far as it will go. This will ensure that the ATM is NOT in an overspeed condition.

4. The pressure regulator - with power and air on - can be checked by using a pressure gauge installed between the pressure regulator and the modulating valve. Pressure should be 55 PSI during operation of the ATM.

5. The speed controller, with power and air off, can only be checked visually for noticable damage. Its internal parts can be checked by removing it from the ATM and placing it on a special test stand.

6. The modulating valve, with power and air off, can be checked for freedom of movement by moving the linkage full open and closed by hand. Checking of the diaphragms cannot be done without disassembly of the valve.

Answer the following statements TRUE or FALSE.

_____1. The solenoid valve linkage should be fully extended when the switch is off.

_____2. The ATM shutoff valve must be able to move 2" for proper operation.

_____3. Pressing in the overspeed trip valve button ensures that there is an overspeed condition.

_____4. The ATM pressure regulator should maintain 65 PSI.

_____5. The modulating valve linkage can be checked for freedom of movement in the same way as the shutoff valve.

Correct Responses to Frame 13: T 1. F 2. F 3. F 4.
T 5.

Frame 14

By now you should know the general principles of operation of the ATM and the procedures for bench checking its components. You should also be able to identify and locate the different components that make up the ATM. Figure 9 is an external view of the ATM. Study figure 9 and identify by name each component indicated. This should enable you to easily locate components for bench checking and troubleshooting the ATM.

NO RESPONSE REQUIRED

SERVICE TEST
WORKBOOK

C3ABR42331-WB-306

Technical Training

Aircraft Environmental Systems Mechanic

MAINTENANCE OF AIR TURBINE MOTORS (ATM)

9 September 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

Environmental Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-WB-306

OBJECTIVES

Given applicable workbook, AFTO Forms and TO, and necessary equipment, perform a minor inspection of the air turbine motor, locating a minimum of two discrepancies, with a maximum of 4 Instructor Assists.

Instructor Initials 1. ____ 2. ____ 3. ____ 4. ____

Given a workbook, AFTO Forms and TO, and necessary equipment, and using a source of hot pressurized air, perform an operational check on the air turbine motor with a maximum of 4 Instructor Assists.

Instructor Initials 1. ____ 2. ____ 3. ____ 4. ____

NOTE: An instructor assist has been defined as limited aid, such as, technical direction, and/or technical interpretation given a student who can proceed no further on his/her own. Be sure to ask any necessary questions before the test begins.

EQUIPMENT

Air Turbine Motor
MA-1A Ground Air Compressor
Ear Protection

INTRODUCTION

As an aircraft environmental systems specialist you will be required to perform both visual and functional inspections of aircraft environmental systems and components. For the visual inspections you would check the items listed on the applicable inspection work cards (AFTO FORM 26) and record all discrepancies on the Maintenance Discrepancy & Work Document Forms (AFTO FORM 781A) and on Maintenance Data Collection Record Forms (AFTO FORM 349) at the back of this workbook. Once the discrepancies have been identified and recorded you must perform whatever maintenance is necessary to take care of them. After all the work has been completed, and before the aircraft is released for flight, you must perform functional checks on the systems/components using the applicable technical orders.

In this work book you will be required to perform a visual inspection of a C-130A aircraft air turbine motor, locate and record at least two discrepancies on applicable forms, and then perform a functional check of the unit. Before performing the functional check you must read and understand this workbook. Notify the instructor when you are ready to begin the project.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

PART 1

1. Obtain the applicable inspection workcard form the instructor and perform a "Minor Inspection on the C-130A aircraft Air Turbine Motor, (located on the left side of the loadbank). Then have the instructor check your work before proceeding.

   Instructor initials, checking work so far completed. ______________

2. Complete the AFTO Forms 349, 781A, using the following information and technical orders.

AIRCRAFT INFORMATION

Serial Number	830557
Aircraft Time	649.3
Number of Engines	4
Engine Serial Numbers:	
No. 1	679210
No. 2	671321
No.3	670323
No.4	678101

ATM INFORMATION

Serial Number	734210
Identification Number	XX4210
Part Number	9410P542
FSC	0520
Total Operating Time	97.5 Hours

NOTE: Some of the information listed above may, or may not be used. Use only the information required on the AFTO Form you are completing.

Today your supervisor dispatched you on a priority 3 workorder to perform a minor inspection on the ATM, that is installed on aircraft I.D. #0557, located in Hanger #A106, on Chanute Air Force Base, Illinois 61868

The Job Control Number for the minor inspection is A527. (Include today's julian date). The Aircraft's workcenter code is A3479, and your workcenter is Q3360.

The time you are required to begin the inspection is the same time that you entered this lab.

3. Upon completion of the AFTO Forms, turn them in to your instructor and correct all mistakes identified by the instructor.

PART 2

1. After the paperwork has been corrected you will perform an operational check of the ATM using instructions contained in this workbook.

2. After the operational check, you must complete the applicable forms to document the check. Using the same information as for the other forms.

The Technical Orders to be used are:

00-20-2-2, Maintenance Documentation for Aircraft.

00-20-5, Aircraft Inspections, Flight Reports, and Supporting Maintenance Documents.

1C-130A-06, Work Unit Code Manual for a C-130 Aircraft.

You must have completed four AF Forms 349 and four blocks on the AFTO form 781A. One block/form for each of the following.

1. Minor Inspection Due.
2. One for each discrepancy found during the inspection (2 discrepancies).
3. Operational Check Due.

AIR TURBINE MOTOR OPERATIONAL CHECKOUT

FOREWORD

This workbook contains the before test, test, and after test procedures for performing an operational checkout of an Air Turbine Motor Trainer. All safety precautions, notes, warnings, and procedures and limitations contained herein will be strictly adhered to. It is the responsibility of the person in charge of this operation to be thoroughly familiar with this publication to ensure that all other personnel involved understand its contents.

A qualified person must be present at all times.

All asterisked (*) items will be performed by qualified individuals only.

BEFORE TEST

WARNING

All applicable AFOSH standards must be followed during this operation. This includes the use of ear protection and removing watches, rings, bracelets, necklaces, and metal rim glasses.

* 1. Start the MA-1A ground power cart according to labeled instructions. Connect the air hose to the bleed air duct.

* 2. Place the CONTROL BLEED AIR SHUTOFF VALVE control box C130 switch to the 'OPEN' position.

TEST

1. Insure that the ATM control panel circuit breaker is in.
2. Place the CONTROL SWITCH in the 'RUN' position.
   RESULT: The ATM should start.

   The shutoff valve and modulating valve should open. The modulating valve may fluctuate to maintain ATM speed as air source pressure changes.
3. Check to see if the generator is rotating.
4. Check the oil vent located under the speed controller. A slight air flow should be felt.

5. Check all tubing and duct connections for air leaks.

6. Check ATM casing for oil leaks.

7. Place the CONTROL SWITCH to 'STOP'.
   RESULT: The ATM should stop.

8. Insure that the shutoff valve and modulating valve close.

AFTER TEST

* 1. Place the CONTROL BLEED AIR SHUTOFF VALVE control box C130 switch to the 'CLOSE' position.

* 2. Shutdown the MA-1A ground air cart and stow the air hose.

MAINTENANCE DATA COLLECTION RECORD

OMB NO.
21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	 HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

27. CORRECTIVE ACTION

28. RECORDS ACTION

MAINTENANCE DATA COLLECTION RECORD

OMB NO.
21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD

19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	 HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N EMPLOYEE NUMBER
1															
2															
3															
4															
5															

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28. RECORDS ACTION

MAINTENANCE DATA COLLECTION RECORD

OMB NO.
21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.
19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME		

ACT LINE	A	B	C	D	E	F	G	H	I		J	K	L	M	N
	TYPE MAINT	COMP POS	WORK UNIT CODE	ACTION TAKEN	WHEN DISC	HOW MAL	UNITS	START HOUR	STOP DAY	STOP HOUR	CREW SIZE	CAT LAB	CMD ACT ID	SCH CODE	EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

27. CORRECTIVE ACTION

28. RECORDS ACTION

MAINTENANCE DATA COLLECTION RECORD

OMB NO.
21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. SRD	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD.
19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME		

ACT LINE	A	B	C	D	E	F	G	H	I		J	K	L	M	N
	TYPE MAINT	COMP POS	WORK UNIT CODE	ACTION TAKEN	WHEN DISC	HOW MAL	UNITS	START HOUR	STOP DAY	STOP HOUR	CREW SIZE	CAT LAB	CMD ACT ID	SCH CODE	EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

27. CORRECTIVE ACTION

28. RECORDS ACTION

PAGE OF PAGES

DATE FROM / /	TO / /	CREW CHIEF	ORGN	LOCATION	MDS	SERIAL NO.

SYM	DATE DISCD / /	WDC	JCN	TAG NO.	CF TO 781A DATED P I / /	TRANSFERRED TO 781K DATE / /	DATE CORRECTED / /
DOC. NO.			DISCREPANCY		TRANSFERRED BY	GRADE	EMPLOYEE NO.
					CORRECTIVE ACTION		
					CORRECTED BY	GRADE	EMPLOYEE NO.
DISCOVERED BY		GRADE	EMPLOYEE NO.		INSPECTED BY	GRADE	EMPLOYEE NO.

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DOC. NO.			DISCREPANCY		TRANSFERRED BY	GRADE	EMPLOYEE NO.
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SYM	DATE DISCD / /	WDC	JCN	TAG NO.	CF TO 781A DATED P I / /	TRANSFERRED TO 781K DATE / /	DATE CORRECTED / /
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MAINTENANCE DISCREPANCY AND WORK DOCUMENT

835 10

PROGRAMMED TEXT

C3ABR42331-PT-307

Technical Training

Aircraft Environmental Systems Mechanic

TURBINE REFRIGERATION DEVICES

12 April 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: 10.0

OBJECTIVE

Relate components of a turbine refrigeration device to their operation with 80% accuracy.

INSTRUCTIONS

This text presents material in small steps called "frames." After each frame you will find a number of statements and you are asked to select the true statement/statements from the list. The answers to the correct statements can be found on the top of the next page. If you selected the correct answers, continue to the next frame.

As you read the text, the turbines will be available for you to see and inspect. If you have any questions ask your instructor.

Supersedes 3ABR42331-PT-307, 27 February 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; DAV - 1

Frame 1

On today's high speed, high altitude jet aircraft, air for operating the air conditioning system for the cockpit or cabin is taken from the last stage of engine compression. This air has a very high temperature, which is usually between 600-900 degrees F. on most aircraft. This air is known as Engine Bleed Air. In this text and on the flightline it is simply known as "EBA." After the heat exchangers cool this EBA as much as possible it is routed to the air cooling turbine, which cools the air further by rapidly expanding the air.

In this text we will discuss the major types of turbines that are used on today's jet aircraft.

Note: Check (✓) the following statements that are true.

_____ 1. The abbreviation for Engine Bleed Air is EBA.

_____ 2. The temperature of Engine Bleed Air is very high.

_____ 3. EBA is tapped off the compressor section of the engine.

_____ 4. The heat exchangers cool the air before it reaches the cooling turbine.

_____ 5. The air is cooled by expanding it.

Answers to Frame 1: 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5. ✓

Frame 2

The four main types of cooling turbines used in today's aircraft are: 1. Oil Sump; 2. Oil Pack; 3. Compressor type; and 4. Variable Nozzle. Cooling turbines are also called Air Cycle Machines.

As the turbine units are being discussed, refer to figure 6 at back of the text, in order to see the location of the components.

The major components of the oil sump turbine are the turbine wheel (1) and fan assembly (6). These two units are connected by a common shaft (15). The turbine wheel is driven by EBA, by way of the nozzle ring (11), which causes a temperature drop by rapidly expanding the air on the outlet side of the turbine wheel. The turbine then drives the fan.

The fan (6) draws ram air across the heat exchanger and at the same time puts a load on the turbine to prevent the turbine from overspeeding.

Note: Check (✓) the statements that are true.

______ 1. The turbine cools the air by rapidly expanding it.

______ 2. The fan draws ram air across the heat exchanger.

______ 3. The fan puts a load on the turbine to prevent overspeeding.

______ 4. The turbine is driven by the fan.

______ 5. The turbine wheel and fan assembly are connected by a common shaft.

______ 6. The four main types of turbines are oil sump, oil pack, compressor, and variable nozzle.

Answers to Frame 2: 1. ✓ 2. ✓ 3. ✓ 4. ___ 5. ✓ 6. ✓

Frame 3

Now that you know the function of the turbine and fan assembly, let's take a look at what the rest of the parts do.

The bearings (9 and 14) support the shaft (15). The preload spring (8) absorbs the end play of the shaft.

The oil for lubricating the bearings is stored in the sump (3). A felt blanket (5) prevents the oil from reaching the bearings in a liquid form. The oil flows slowly through the wick (4) to the blanket (5) and then to the bearings, (9 and 14). The slinger rings (2) draw an oil mist from the blanket (5) across the bearings (9 and 14), then returns the oil to the sump through drilled passages. The labyrinth seals (oil seals) (10 and 13) keep the oil from getting into the cold air duct and the ram air duct.

Note: Check (✓) the following statements which are true.

_____ 1. The slinger rings draw oil across the bearings.

_____ 2. The bearings support the shaft.

_____ 3. The labyrinth seal keeps the oil from getting into the cold air and ram air ducts.

_____ 4. The felt blanket keeps the oil warm.

_____ 5. The felt blanket keeps the oil from reaching the bearings in liquid form.

_____ 6. The wick keeps the oil from reaching the felt blanket.

Answers to Frame 3: 1. ✓ 2. ✓ 3. ✓ 4. ___ 5. ✓ 6. ___

Frame 4

Let's see how oil is added to an oil sump type turbine. The amount of oil varies with type of aircraft. You will have to look in the technical order to find the correct amount. Some aircraft turbines have sight gages, so you can tell at a glance what the oil level is. However, some turbines do not have a sight gage so the oil must be measured before it is poured into the turbine unit. For this you have to use a measuring cylinder (figure 1). It is graduated in Cubic Centimeters (CCs). Some aircraft also use a dipstick to check the level of oil.

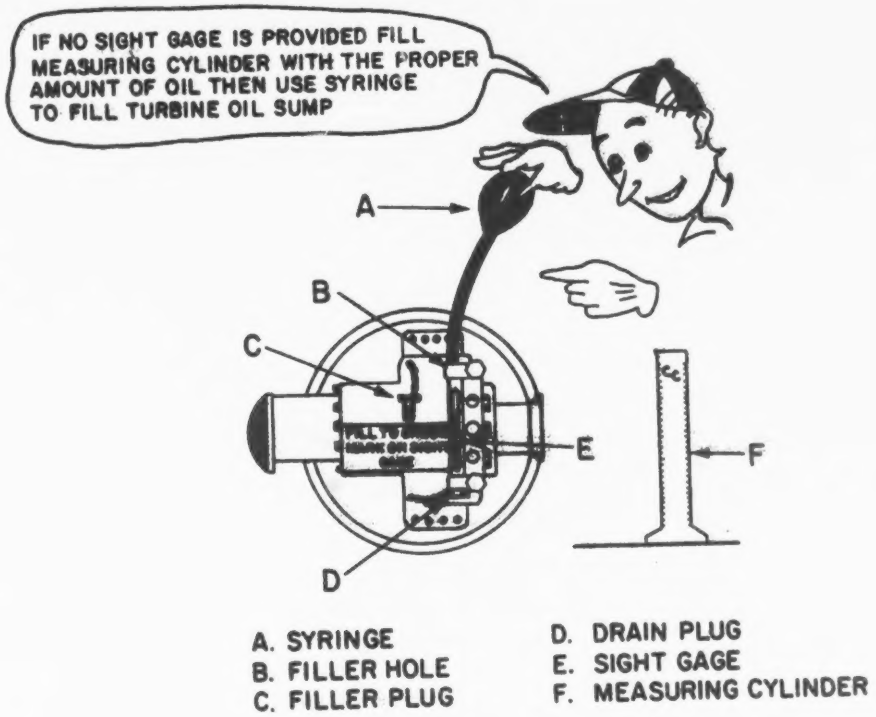

IF NO SIGHT GAGE IS PROVIDED FILL MEASURING CYLINDER WITH THE PROPER AMOUNT OF OIL THEN USE SYRINGE TO FILL TURBINE OIL SUMP
A
B
C
D
E
F
A. SYRINGE
B. FILLER HOLE
C. FILLER PLUG
D. DRAIN PLUG
E. SIGHT GAGE
F. MEASURING CYLINDER

Figure 1. Turbine Servicing.

Oil is changed every so many flying hours. This again varies from aircraft to aircraft and you must look in the TO for the exact time.

Important Note: Never overfill the turbine unit when adding oil. It is just as bad to overfill a turbine as it is to underfill one. Over filling will cause oil smoke to get into the cabin.

Note: Check (✓) the following statements that are true.

_____ 1. The correct amount of oil used in a turbine is found in the technical order.

_____ 2. Measuring cylinders are graduated in CCs.

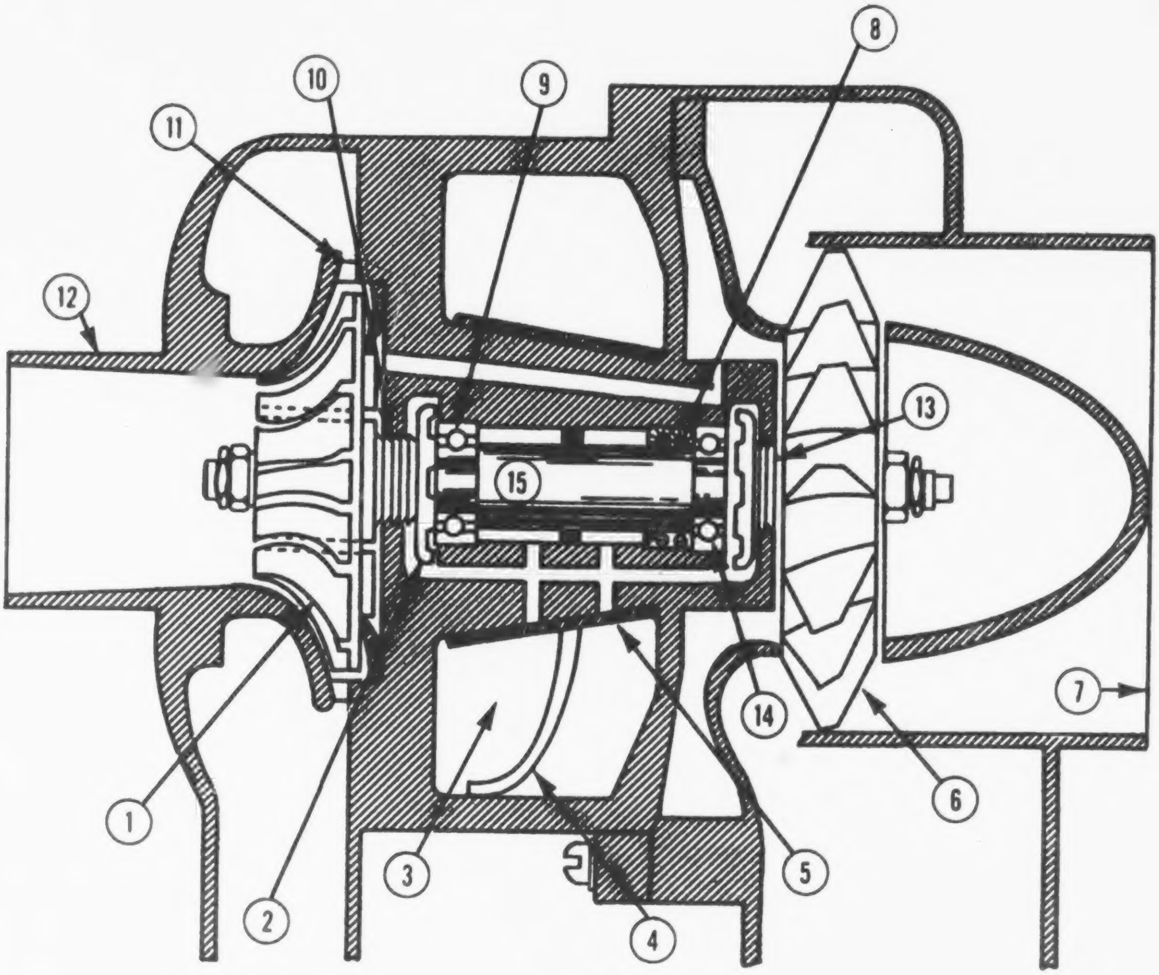
_____ 3. The oil in the turbine unit is changed after so many hours of flying time.

_____ 4. Never overfill the turbine unit.

Answers to Frame 4: 1. ✓ 2. ✓ 3. ✓ 4. ✓

Frame 5

Put figure 6 away and fill in the blanks in figure 2 below:



⑧
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① ____________

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⑥ ____________

⑦ ____________

⑧ ____________

⑨ ____________

⑩ ____________

⑪ ____________

⑫ ____________

⑬ ____________

⑭ ____________

⑮ ____________

Figure 2. Oil Sump Type Turbine.

Refer to figure 6 at the back of the text for the answers to Frame 5.

Frame 6

Now let's discuss the oil pack type cooling turbine that is shown in figure 3. It is much the same as the oil sump type that we have just discussed with the exception that the sump is packed with cotton.

To service the oil pack type turbine with oil you will have to observe the following procedures:

1. Remove the turbine from the aircraft.
2. Take the plug out of the drain hole.
3. Turn the turbine so the drain hole is up.
4. Add the amount of oil that the TO specified.
5. Allow the turbine to remain in that position for 20 to 30 minutes. (This allows the oil to soak into the cotton.)
6. Rotate the turbine unit so the drain hole is down.
7. Allow to remain in this position for 20 to 30 minutes, this drains the excessive oil.
8. Install drain plug, and install turbine in the aircraft.

Note: Check (✓) the statement(s) that are true.

_____ 1. The oil pack type turbine is lubricated by soaking cotton in the sump with oil.

_____ 2. The cotton is soaked for 20 to 30 minutes.

_____ 3. The cotton is drained for 20 to 30 minutes.

_____ 4. The oil pack type turbine is basically the same as the sump type.

_____ 5. The oil in an oil pack is serviced through the fill hole of the unit.

_____ 6. The amount of oil is specified in the TO.

Answers to Frame 6: 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5. ___ 6. ✓

Frame 6 (Cont'd)

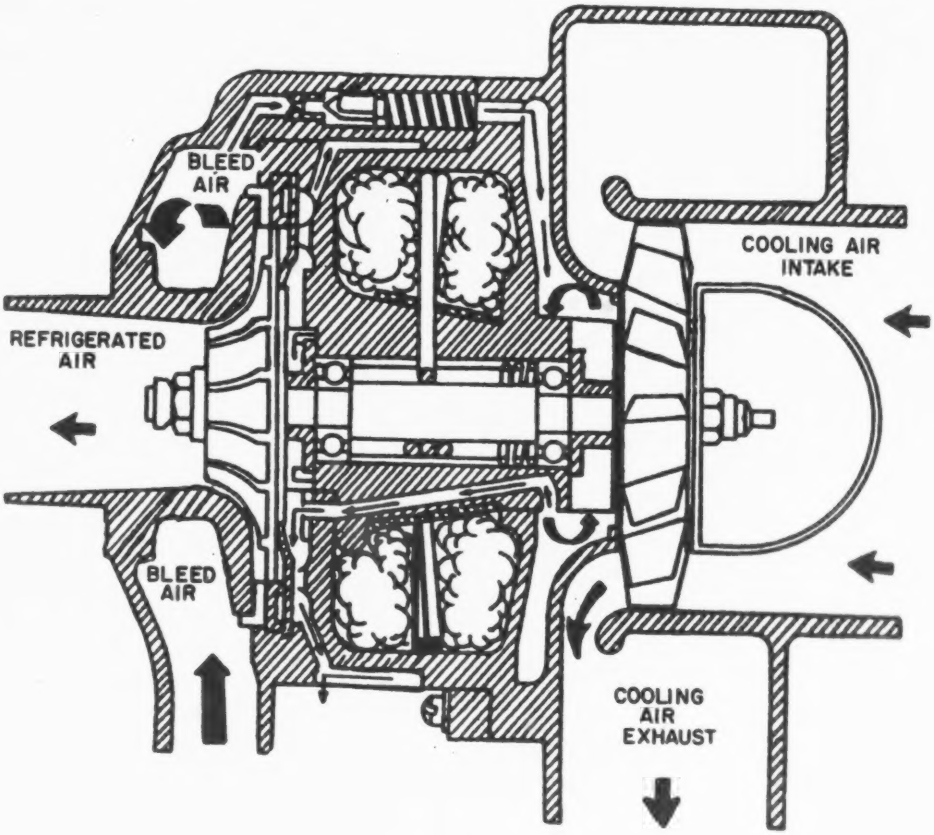

BLEED AIR
REFRIGERATED AIR
COOLING AIR INTAKE
BLEED AIR
COOLING AIR EXHAUST

Figure 3. Turbine - Oil Pack Type.

Frame 7

Now let's discuss the compressor type turbine. This type turbine is much the same as the last two with the exception that EBA is routed through the fan and turbine wheel. Consider figure 4 as we discuss the airflow.

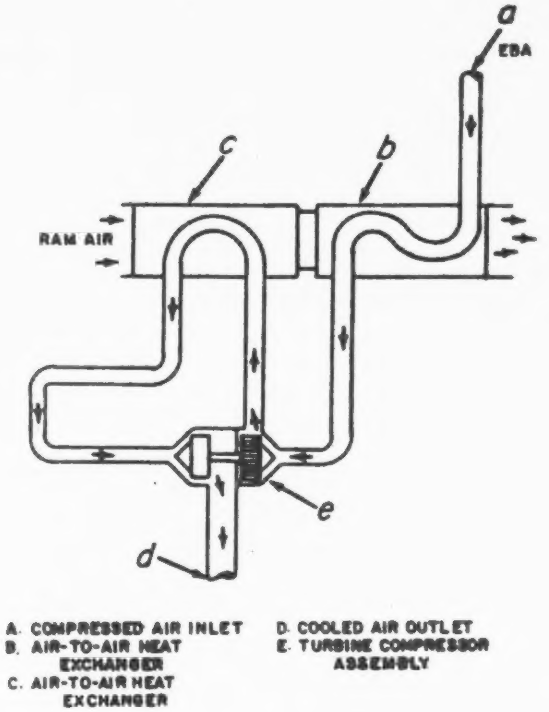

a
EBA
c
b
RAM AIR
e
d
A. COMPRESSED AIR INLET
B. AIR-TO-AIR HEAT EXCHANGER
C. AIR-TO-AIR HEAT EXCHANGER
D. COOLED AIR OUTLET
E. TURBINE COMPRESSOR ASSEMBLY

Figure 4. Turbine Compressor Cooling System.

Engine Bleed Air enters at the inlet port (a) and passes through the primary heat exchanger (b). The air then enters the compressor end of the turbine assembly (e) where the pressure is increased. The air then passes through the secondary heat exchanger (c) for a further reduction of temperature. Then, the air enters the turbine wheel where the air is cooled further by rapid expansion and then routed to the cooling air outlet (d).

Note: Check (✓) the following statements that are true.

_____ 1. Engine Bleed Air is routed to both the compressor and the turbine wheel in a compressor type turbine.

_____ 2. The compressor end of the turbine assembly compresses air.

_____ 3. The turbine wheel by rapid expansion cools the engine bleed air in a compressor type turbine.

_____ 4. Compressor type turbines are much the same as a sump type turbine.

Answers to Frame 7: 1. ✓ 2. ✓ 3. ✓ 4. ✓

Frame 8

The variable nozzle turbine is the only cooling turbine that maintains a constant speed. As you can see in figure 5 below, the wider open the nozzle blades (a) are the faster the turbine wheel will rotate. The further closed the nozzle blades are, the slower the turbine wheel will rotate. An actuator opens and closes the nozzle blades. In this way the turbine can be made to run at a constant speed of approximately 43,000 revolutions per minute (rpm). This allows a constant supply of refrigerated air to the cockpit.

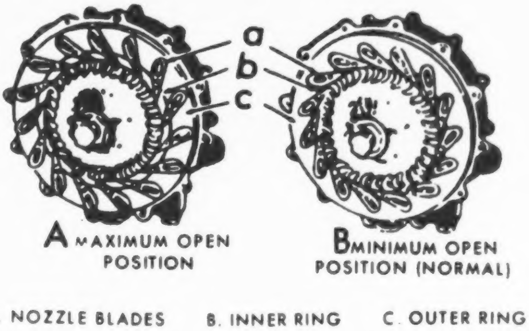


Figure 5. Variable Inlet Nozzles.

Note: Check (✓) the statements that are true.

_____ 1. Closing the nozzle blades decreases the speed of the turbine wheel.

_____ 2. The variable nozzle turbine keeps a constant speed by changing the position of the nozzle blades.

_____ 3. Opening the nozzle blades decreases the speed of the turbine blades.

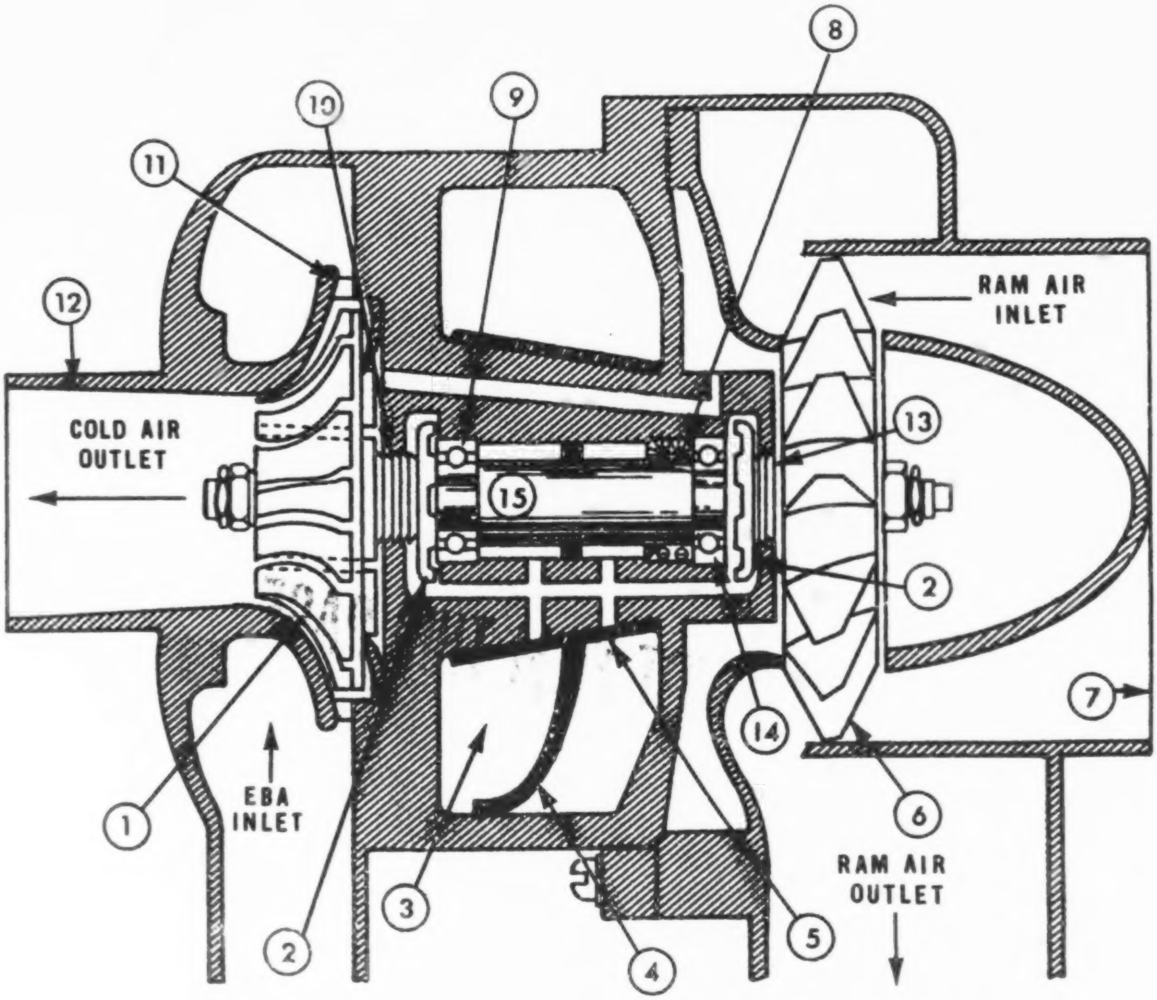
_____ 4. Keeping the turbine wheel at a constant speed maintains a steady supply of conditioned air to the cockpit.

Answers to Frame 8: 1. ✓ 2. ✓ 3. __ 4. ✓

Frame 9

This completes the discussion on the major types of cooling turbines used in aircraft systems. Before we close there is one very important thing to remember --- never overfill the turbine unit with oil. The bearings on an overfilled turbine unit seize faster than one with too little oil in it.

No Response Required


8
10
9
11
12
COLD AIR OUTLET
RAM AIR INLET
13
15
2
7
14
6
EBA INLET
1
RAM AIR OUTLET
3
2
4
5

① TURBINE WHEEL
② SLINGER RING
③ OIL SUMP
④ WICK
⑤ BLANKET
⑥ FAN
⑦ RAM AIR INLET
⑧ PRE-LOAD SPRING
⑨ BEARING
⑩ LABYRINTH SEAL
⑪ NOZZLE RING
⑫ COLD AIR OUTLET
⑬ LABYRINTH SEAL
⑭ BEARING
⑮ SHAFT

Figure 6. Oil Sump Type Turbine.

PROGRAMMED TEXT
C3ABR42331-PT-311

Technical Training

Aircraft Environmental System Mechanic

FIGHTER-BOMBER WINDSHIELD CLEARING SYSTEM

8 July 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 9.7

OBJECTIVE

Relate components of the fighter-bomber windshield clearing system to their operation with 80% accuracy.

INSTRUCTIONS

This programmed text gives information in small steps called "frames." After each frame you are asked to complete a statement or determine the answer to a question. Read the material presented and make your response as directed. DO NOT MARK IN THIS TEXT. After you have made your response, compare your answer with the correct answer given above the following frame. If necessary, you may go back to check information previously given, but do not skip ahead.

Supersedes 3ABR42331-PT-311, 17 July 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

The windshield clearing system is made up of two small systems; (1) the rain removal system and (2) the windshield wash system. The rain removal system will keep the windshield free of rain so the pilot's view is not obstructed. The windshield wash system is used to remove film, insects, and foreign material. In this text each system will be discussed separately, then how they work together.

Answer the statements as true (T) or false (F).

_____1. Two smaller systems make up the windshield clearing system.

_____2. The rain removal system keeps the windshield free of rain.

_____3. Insects on the windshield are removed by the windshield wash system.

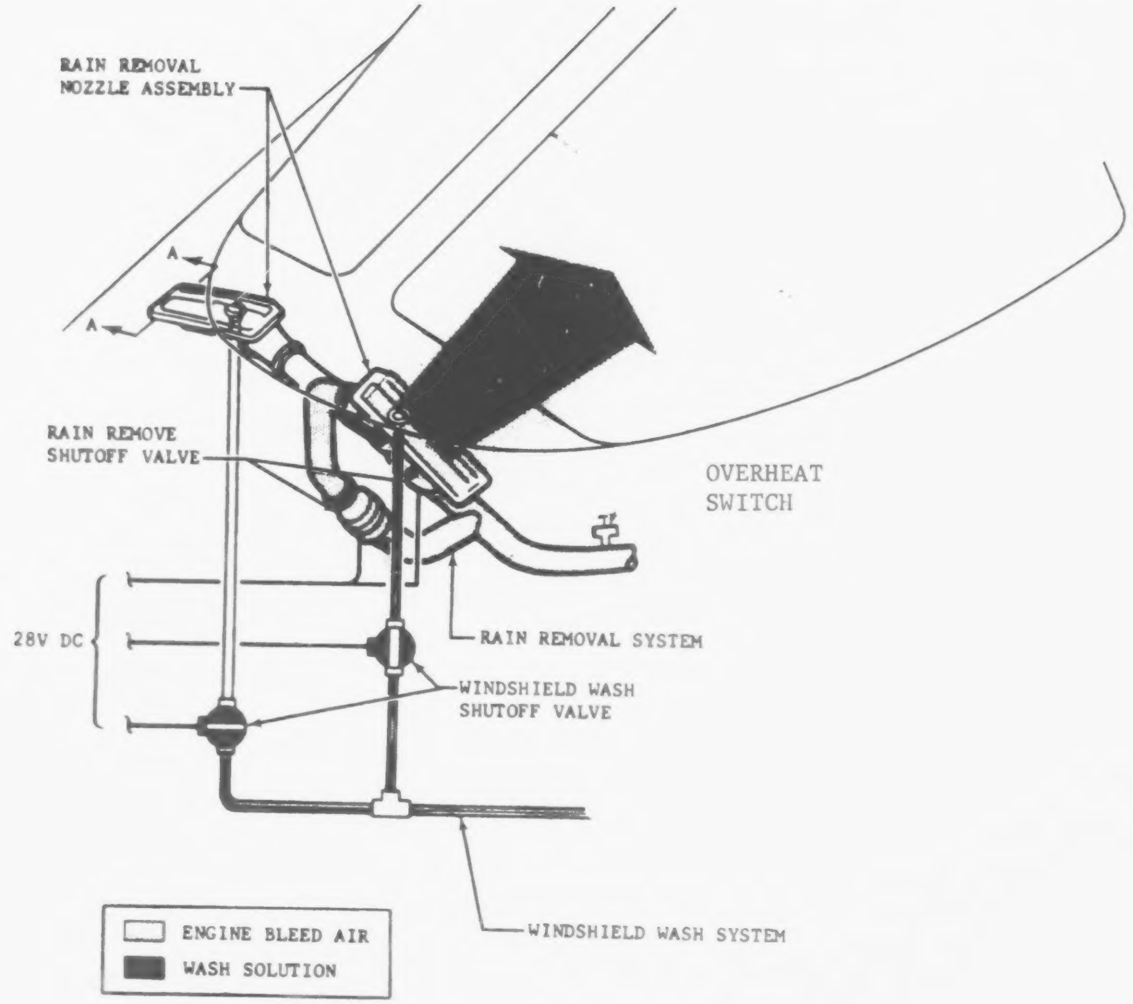

RAIN REMOVAL NOZZLE ASSEMBLY
A
A
RAIN REMOVE SHUTOFF VALVE
OVERHEAT SWITCH
28V DC
RAIN REMOVAL SYSTEM
WINDSHIELD WASH SHUTOFF VALVE
WINDSHIELD WASH SYSTEM
☐ ENGINE BLEED AIR
■ WASH SOLUTION

Figure 1.

CORRECT RESPONSES TO FRAME 1: 1. T 2. T 3. T

Frame 2

The rain removal system directs a blast of hot air over the windshield. The hot air is sent through ducts to two rain removal shutoff valves. When these valves are opened, air is directed through fixed nozzles. The nozzles are found at the front of each windshield, figure 1. The rain removal nozzles have long slots. These slots discharge air in an upward direction across the windshield. The slots are open and will collect rain when the system is not in operation. A gravity water drain is put in the nozzles to keep water from accumulating in the air supply ducts and nozzle assembly. The water drain has a spring type diaphragm that will shut off during nozzle operation. This is to stop hot air leakage.

Complete the statements.

1. Air for rain removal is taken from the ____________ ____________ system.

2. There are ____________ rain removal shutoff valves.

3. The ________________ receive air directly from the rain removal shutoff valves.

4. The drain assembly is ________________ operated.

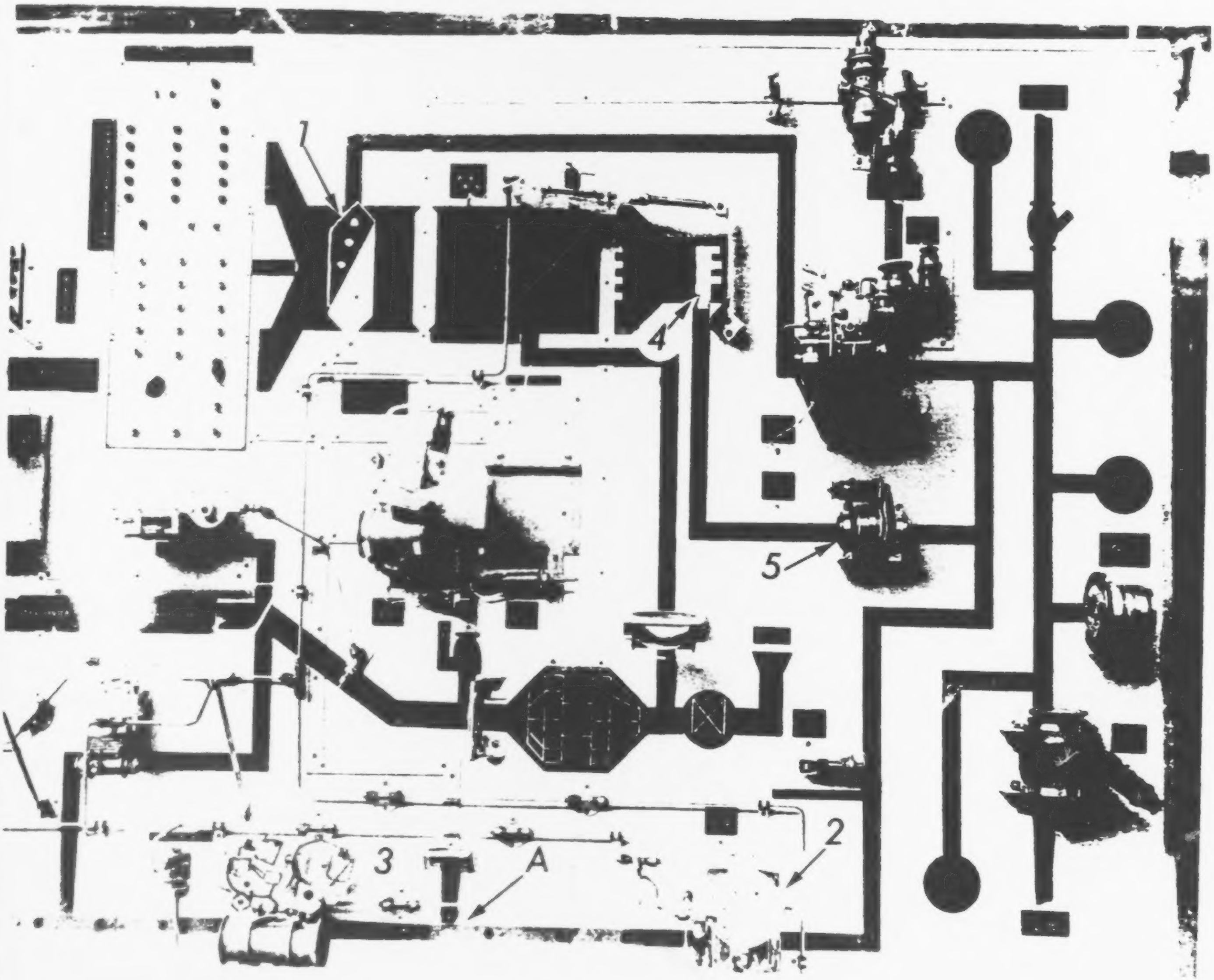


Figure 2.

CORRECT RESPONSES TO FRAME 2: 1. Hot Air 2. Two 3. Nozzles

4. Gravity

Frame 3

Look at figure 2. Air for rain removal comes from the hot air system. The hot air system temperature is controlled at 390°F. Temperature is controlled by a mix of cool air from the air-to-air heat exchanger (1) with hot air from the hot air temperature control valve (2) at point A. This air is kept at a pressure of 45 psi by the hot air pressure regulator (3). When the rain removal system is operated, a large flow of air is required to maintain 45 psi and control the temperature at 390°F. This will cause an additional demand on the air-to-air heat exchanger to cool the air. To fix this problem an additional set of ejector nozzles (4) and an ejector valve (5) are used. When the rain removal system is turned on the ejector valve will open. Air will pass through the ejector nozzles and make a low pressure area in the ram air duct. The low pressure area is downstream of the heat exchanger. The result is an increase in ram air flow across the heat exchanger.

Complete the statements.

1. The ejector valve will increase the effectiveness of the ________________ ________________.

2. The ______________ ________________ is open during rain removal operation.

3. The temperature of the air used for rain removal is ____________.

4. The pressure of the air used for rain removal is __________.

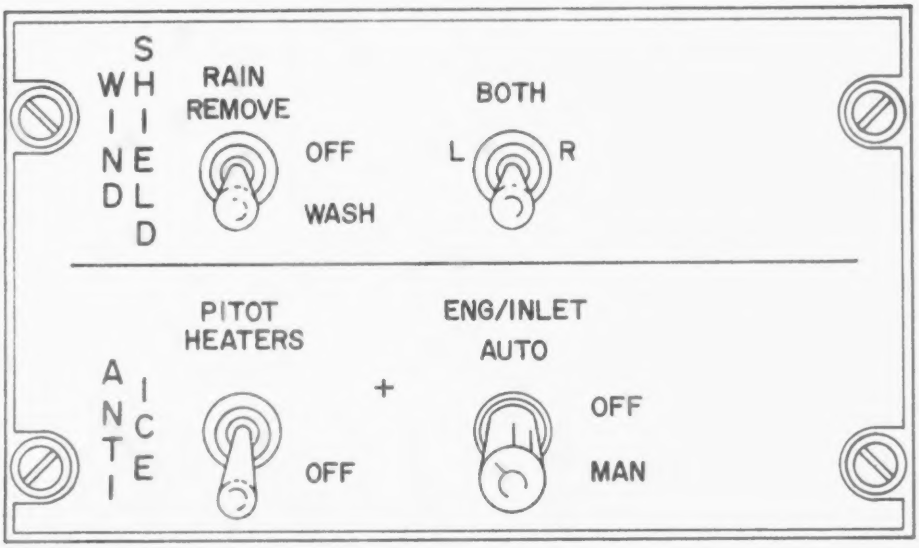

WINDSHIELD
RAIN REMOVE
OFF
WASH
BOTH
L
R
ANTI ICE
PITOT HEATERS
OFF
ENG/INLET
AUTO
OFF
MAN

Figure 3.

CORRECT RESPONSES TO FRAME 3. 1. Heat exchanger 2. Ejector valve

3. 390°F 4. 45 psi

Frame 4

There are two rain removal shutoff valves and a bleed air ejector shutoff valve. The three valves are solenoid controlled, pneumatically actuated shutoff valves. They are opened by placing the windshield selector switch (figure 3) to the L (left), R (right), or BOTH positions. The rain removal switch must be in the RAIN REMOVAL position for the system to work. When the rain removal switch is in RAIN REMOVAL, the solenoids of the rain removal shutoff valves and the bleed air ejector shutoff valve are energized. This will cause the valves to open pneumatically. The rain removal shutoff valves can be closed in two ways. The first way is to place the rain removal valve switch to the OFF position. This will also close the bleed air ejector shutoff valve. The other way is by the windshield thermal overheat switch. The switch is normally open and is found in the hot air supply duct. It is upstream of the rain removal shutoff valves. When in normal operation and the air temperature gets above 445°F, the windshield thermal overheat switch will close. This will cause the overheat relay to energize and the WINDSHIELD HOT lamp in the cockpit will light. The solenoids of the rain removal shutoff valves will be deenergized and cause the valves to close. When there is an overheat condition, the bleed air ejector shutoff valve will stay open. This will cause greater cooling through the air-to-air heat exchanger. The purpose is to return the hot air system temperature to normal. When the temperature drops below 445°F the rain removal system will work normally again.

Answer the statements as true (T) or false (F).

_____1. The rain removal shutoff valves are opened by the WINDSHIELD CLEAR BUTTON.

_____2. There are two means of closing the rain removal shutoff valves.

_____3. The secondary means of closing the rain removal shutoff valves is to place the rain removal switch to OFF.

_____4. The overheat switch sends power to close the rain removal shutoff valves at 390°F.

CORRECT RESPONSES TO FRAME 4: 1. F 2. T 3. F 4. F

Frame 5

The second part of the windshield clearing system is the windshield wash system. The windshield wash system will operate during landing, takeoff, and when the aircraft is waiting for takeoff. The windshield wash and rain removal systems must not be used at supersonic speeds. Poor air conditioning and overtemperature conditions could exist due to high bleed air temperatures.

Answer the statements as true (T) or false (F).

_____1. The windshield wash system is designed for operation during takeoff.

_____2. The wash system may be operated at any time.

_____3. The windshield wash is a part of the windshield clearing system.

Both the windshield wash and rain removal systems are used to wash the windshield. The windshield wash system will send the wash solution to the windshield at 15 psi pressure. This pressure will not be enough to force the solution over the entire windshield. Pressure from the rain removal system is used. A blast of 45 psi of hot air from the rain removal nozzles will force the solution over the whole windshield. The mix of the hot air and wash solution will make the cleaning action.

Answer the statements as true (T) or false (F).

_____1. The windshield wash system does operate with the rain removal system.

_____2. A flow of air from the rain removal nozzles forces the wash solution across the windshield.

_____3. The windshield wash system needs the air used for rain removal for operation.

_____4. The rain removal system and windshield wash system operate at the same time.

CORRECT RESPONSES TO FRAME 5: 1. T 2. F 3. T

CORRECT RESPONSES TO FRAME 6: 1. T 2. T 3. T 4. T

Frame 7

Look at figure 4. The wash solution is stored in a one gallon tank. To force the solution to the windshield wash nozzles, pressure is applied to the top of the solution in the tank. Air for head pressure is taken downstream of the service air-to-air heat exchanger. This air is regulated to 15 psi by a pressure regulating valve. The air goes through a check valve (A) and to the wash solution tank. A 20 psi safety relief valve (B) will keep pressure from building up too high, should the pressure regulator fail. The washing action is caused by selecting L, R, or BOTH on the windshield selector switch. The rain removal switch must also be placed in the wash position. When this happens, 28V DC is sent to the windshield wash shutoff valves (C) and the rain removal shutoff valves that will cause them to open. Once either or both of the windshield wash valves are open, the head pressure forces the wash solution through tubing to the nozzles. The 45 psi used for rain removal will then force the wash solution on the windshields for cleaning. When the rain removal switch is put to WASH, a time delay relay is energized. This timer allows the windshield wash system to operate for 5 seconds. If the pilot wants more cleaning, the rain removal switch must again be put to the WASH position.

Answer the statements as true (T) or false (F).

_____1. The wash solution is stored in a one gallon tank.

_____2. The head pressure of the tank is normally 15 psi.

_____3. Only one side of the windshield can be cleared at a time.

_____4. The 45 psi used for rain removal is also used with the windshield wash system.

_____5. The timer relay allows the windshield wash system to operate for 5 seconds.

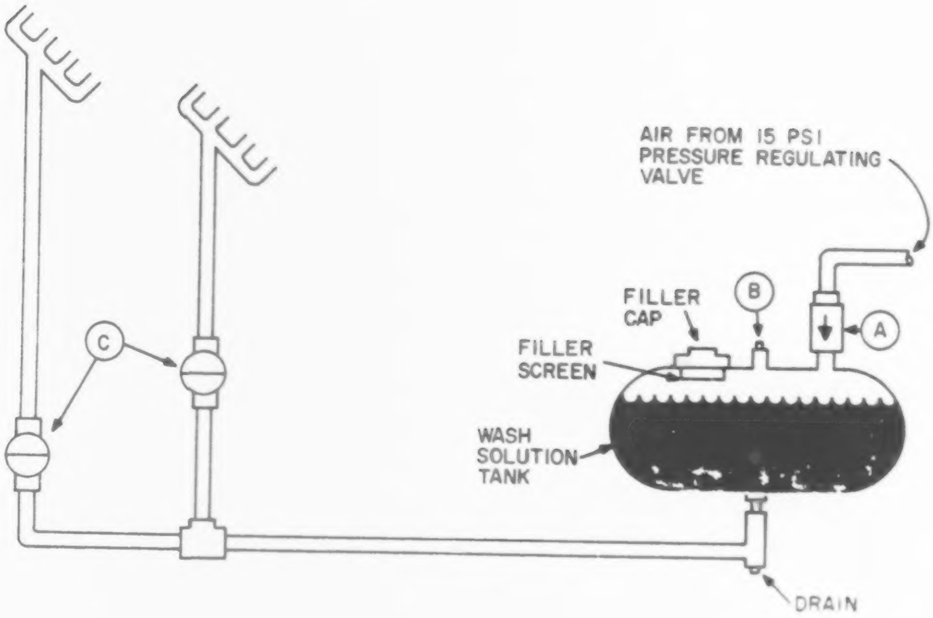

AIR FROM 15 PSI
PRESSURE REGULATING
VALVE
FILLER
CAP
B
A
FILLER
SCREEN
C
WASH
SOLUTION
TANK
DRAIN

Figure 4.

CORRECT RESPONSES TO FRAME 7: 1. T 2. T 3. F 4. T

5. T

Frame 8

The windshield selector switch will allow the selection of L, R, or BOTH windshields for wash or rain removal. The rain removal and windshield wash valves are energized open. When the selector switch is put to the L position (figure 5A) a cam on the bottom of the switch is forced to the left. This will open the contacts for power to the right rain removal and windshield wash valves. The same procedure happens when R is selected (figure 5B). When BOTH is selected (figure 5C) the cam will stay in a neutral position and will allow the circuits for both rain removal shutoff valves to be completed.

Answer the statements as true (T) or false (F).

_____1. Positioning the windshield selector switch to R breaks the power circuit to the left windshield wash and rain removal valve.

_____2. Positioning the windshield selector switch to BOTH breaks the power circuit to the left and right windshield wash and rain removal valves.

_____3. Positioning the windshield selector switch to the L position completes the circuit for the left windshield wash and rain removal valves, when the rain removal switch is in rain removal.

CORRECT RESPONSES TO FRAME 8: 1. T 2. F 3. F

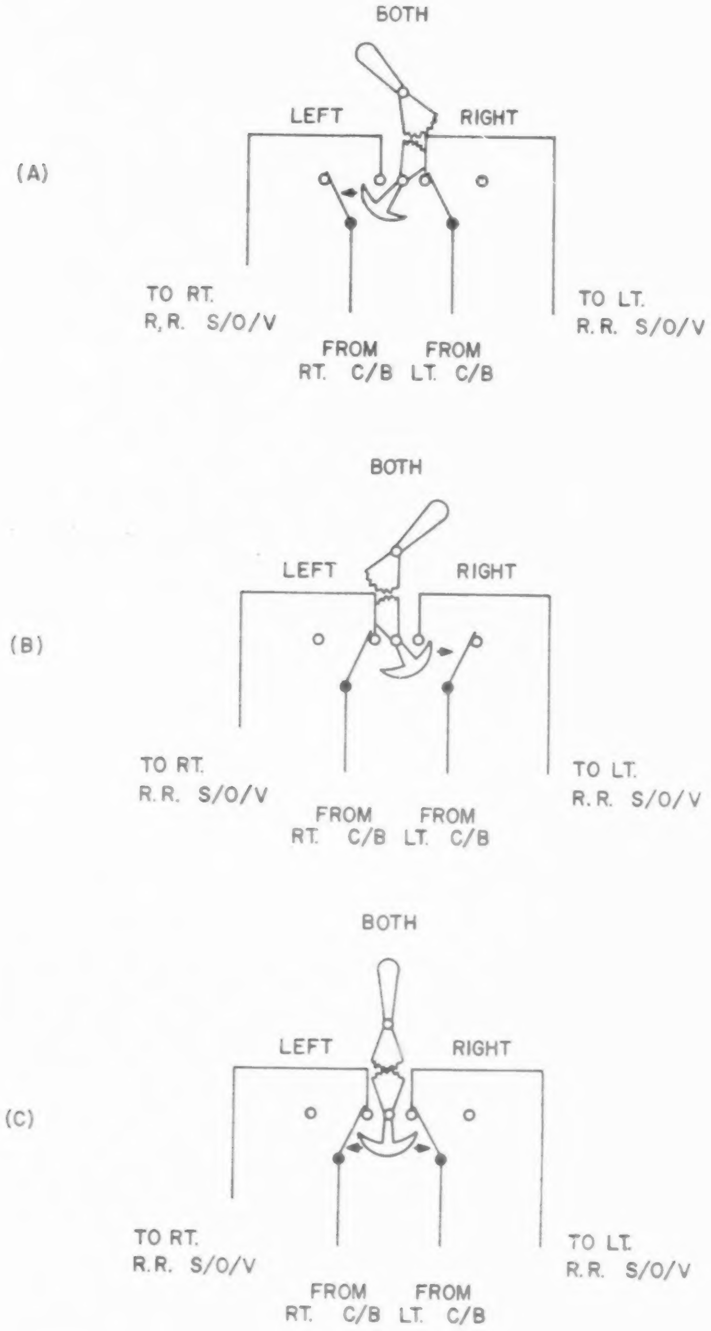

(A)
BOTH
LEFT
RIGHT
TO RT. R,R. S/O/V
TO LT. R.R. S/O/V
FROM RT. C/B
FROM LT. C/B
(B)
BOTH
LEFT
RIGHT
TO RT. R.R. S/O/V
TO LT. R.R. S/O/V
FROM RT. C/B
FROM LT. C/B
(C)
BOTH
LEFT
RIGHT
TO RT. R.R. S/O/V
TO LT. R.R. S/O/V
FROM RT. C/B
FROM LT. C/B

Figure 5.

WORKBOOK
C3ABR42331-WB-311

Technical Training

Aircraft Environmental System Mechanic

ADVANCED FIGHTER-BOMBER WINDSHIELD CLEARING SYSTEM

28 July 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

Environmental/Pneudraulic Branch
Chanute AFB, Illinois

C3ABR42331-WB-311

ADVANCED FIGHTER-BOMBER WINDSHIELD CLEARING SYSTEM COMPONENT IDENTIFICATION, OPERATIONAL CHECK AND TROUBLESHOOTING

OBJECTIVE

Using a wiring diagram and multimeter, and working in a group of not more than two students, perform an operational check and troubleshoot malfunctions on the fighter-bomber windshield clearing system trainer locating the cause for 4 of 5 malfunctions given.

EQUIPMENT

Trainer 4024, Advanced Fighter-Bomber Air Conditioning System
Multimeter
Wiring Diagram, Windshield Clearing System

PROCEDURE

1. REMOVE ALL JEWELRY. Report to the laboratory instructor and tell him of the lesson you are working on. The instructor will have the necessary materials and trainer for your use.

2. This workbook is in three sections:

   I. Location and identification of system components.
   II. Windshield clearing system operational check.
   III. Troubleshooting (trainer).

SECTION I

LOCATION AND IDENTIFICATION OF COMPONENTS

1. Using the trainer and figure 1, find each of the lettered parts. Write the number that goes with the name in the blank spaces.

   a. _____ Air source switch.
   b. _____ Windshield rain removal switch.
   c. _____ Windshield overheat simulation switch.
   d. _____ Windshield hot simulation light.
   e. _____ Windshield anti-ice control panel.
   f. _____ Windshield selector switch.

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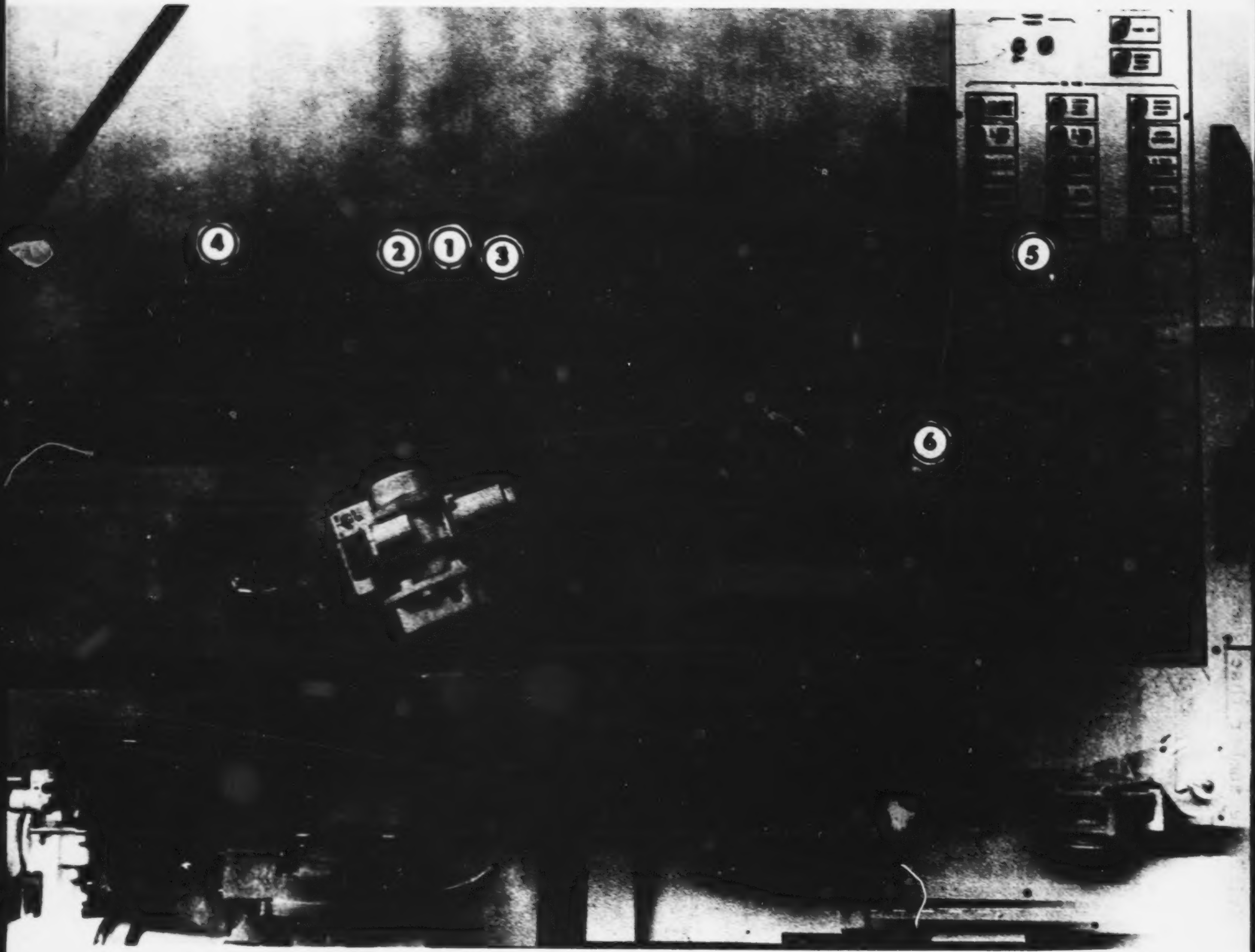

Figure 1.

2. Using the trainer and figure 2, find each of the lettered parts. Write the number that goes with the name in the blank space.

a. _____ Right windshield wash SOV.

b. _____ Left windshield wash SOV.

c. _____ Right rain removal SOV.

d. _____ Left rain removal SOV.

e. _____ Windshield overheat sensor.

f. _____ Fixed nozzles.

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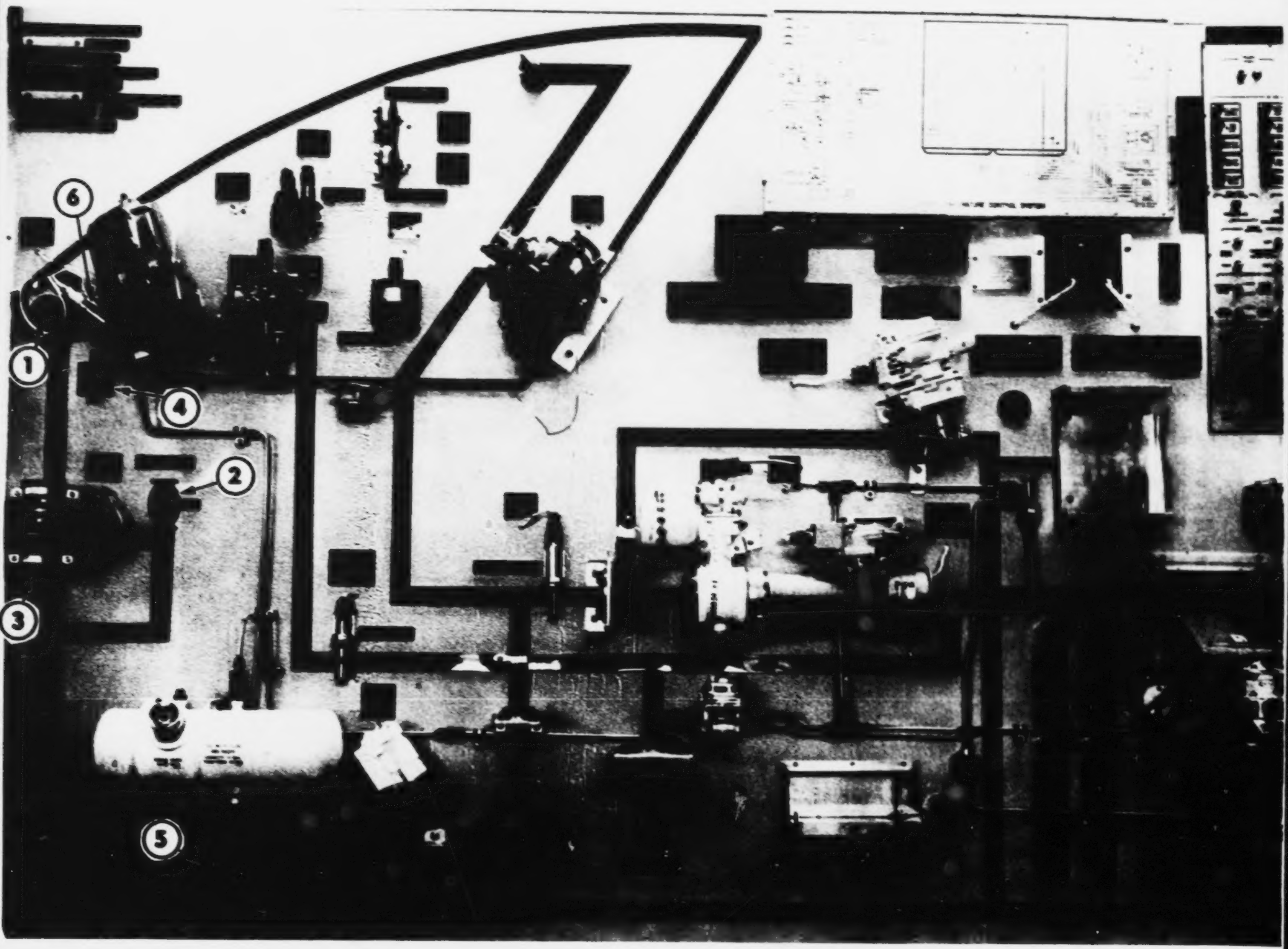

Figure 2.

BEST COPY AVAILABLE

3. Using the trainer and figure 3, find each of the lettered parts. Write the number that goes with the name in the blank space.

a. _____ Ejector valve.

b. _____ Hot air pressure regulator.

c. _____ Hot air temperature control valve.

d. _____ Hot air temperature sensor.

e. _____ Ejector nozzle.

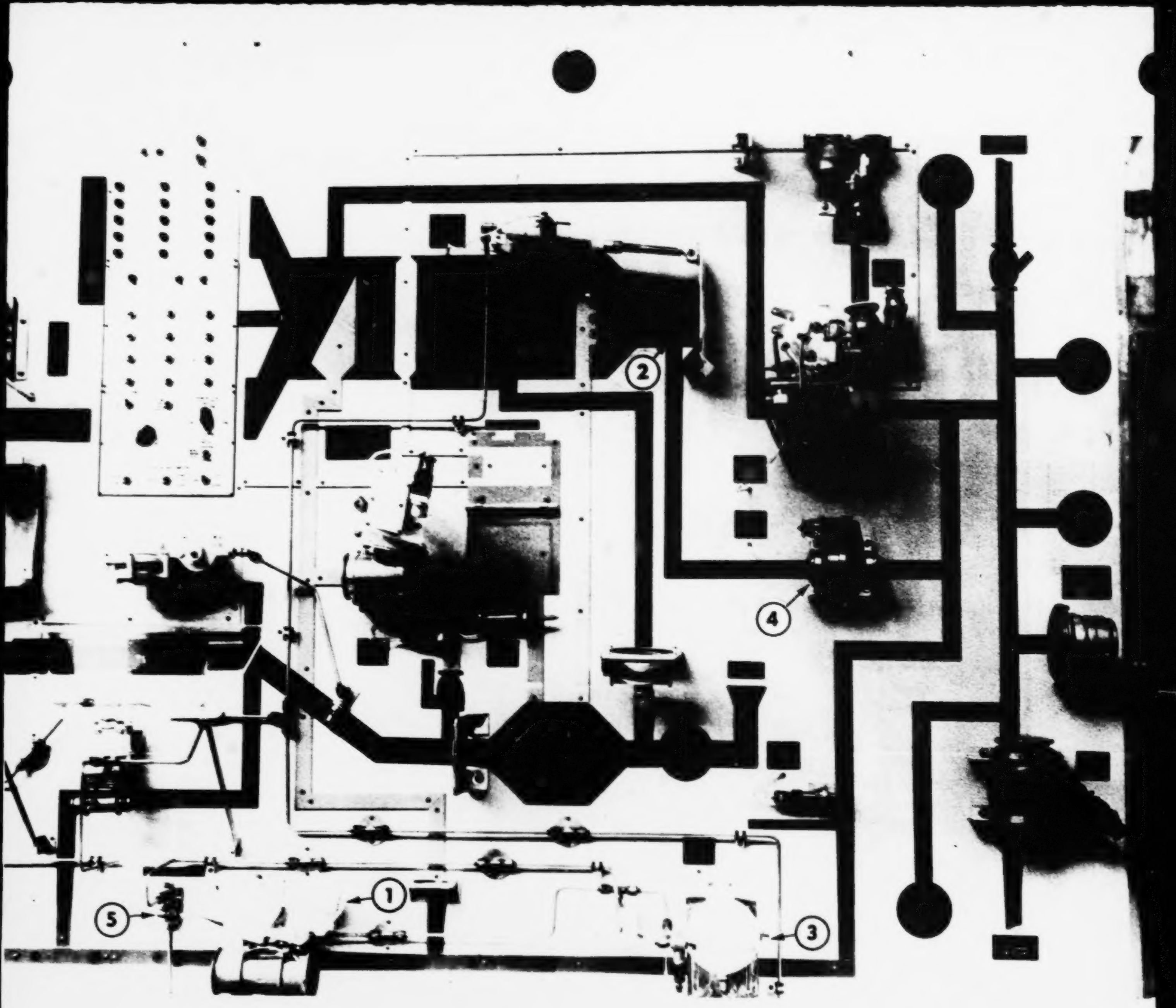

Figure 3.

Answers, Figure 1.

a. 4

b. 2

c. 6

d. 5

e. 1

f. 3

Answers, Figure 2.

a. 4

b. 6

c. 2

d. 3

e. 5

f. 1

Answers, Figure 3.

a. 4

b. 1

c. 3

d. 5

e. 2

SECTION II

WINDSHIELD CLEARING SYSTEM
OPERATIONAL CHECK

PROCEDURE

Follow the step-by-step procedure for operating the windshield clearing system. Be sure to do each step as told. If you can not do the steps tell the instructor.

1. Preparation

a. Find the wall locker in the F-111 laboratory. Get the windshield clearing wiring schematic and a multimeter from the locker.

b. Connect the trainer electrical leads, located on the left end of the trainer, to the wall receptacles behind the trainer.

c. Turn on the trainer air source located behind trainer.

d. Push in all the trainer circuit breakers.

POSITION THE SWITCHES AS FOLLOWS

SWITCH	LOCATION	POSITION
Trainer switch	Top C/B panel	ON
Circuit breakers	C/B panel	IN
Turbine bypass overtemperature	Simulator panel	< 170°F
Turbine overtemperature switch	Simulator panel	< 350°F
Windshield overheat switch	Simulator panel	< 445°F
Trouble switch	Left end of trainer	Down position
Air source switch	Air conditioning panel	OFF

RECHECK ALL SWITCH POSITIONS

SWITCH	OPERATING COMPONENT	RESULT OR POSITION
Ground air source switch ON		
DEPRESS the left engine start switch momentarily	Pressure regulating valve	Closed
	Hot air temp control valve	Closed
DEPRESS the left engine starter overspeed cutout switch momentarily	Pressure regulating valve	Open
	Hot air temp control valve	Open
The left engine is running so there is no need for the ground air source. The right engine will be started with bleed air from the left engine.		
Ground air source switch OFF		
DEPRESS right engine starter switch momentarily	Pressure regulating valve	Closed
	Hot air temp control valve	Closed
DEPRESS right engine starter switch momentarily	Pressure regulator valve	Open
	Hot air temp control valve	Open
Air source selector to BOTH	Left and right bleed air check and shutoff valves	Open

Note: With both engines running and the air source switch in the both position there is air for the windshield clearing system. On the windshield clearing system panel there are two switches; RAIN REMOVAL SWITCH and the WINDSHIELD SELECTOR SWITCH. The rain removal switch has three positions, RAIN REMOVAL, WASH AND OFF. The windshield selector switch has three positions, L (LEFT), BOTH AND R (RIGHT).

SWITCH POSITION	OPERATING COMPONENT	RESULT OR POSITION
Windshield selector switch to BOTH		
Rain removal switch to the RAIN REMOVAL position	Left rain removal SOV Right rain removal SOV Ejector valve	Open Simulated Open Open
Windshield selector switch to LEFT	Left rain removal SOV Right rain removal SOV Ejector valve	Open Closed Open
Windshield selector switch to RIGHT	Right rain removal SOV Left rain removal SOV Ejector valve	Simulated Open Closed Open
Windshield selector switch to BOTH		
Rain removal switch WASH momentarily	Left windshield wash SOV Left rain removal SOV Right windshield wash SOV Right rain removal SOV Ejector valve	Open 5 sec Open 5 sec Simulated Open 5 sec Simulated Open 5 sec Open 5 sec
Windshield selector switch to LEFT		
Rain removal switch to WASH momentarily	Left windshield wash SOV Left rain removal SOV Ejector valve	Open 5 sec Open 5 sec Open 5 sec
Windshield selector switch to RIGHT		
Rain removal switch to WASH momentarily	Right windshield wash SOV Right rain removal SOV Ejector valve	Simulated Open 5 sec Simulated Open 5 sec Open 5 sec

SWITCH POSITION	OPERATING COMPONENT	RESULT OR POSITION
Windshield selector switch to BOTH		
Rain removal switch to RAIN REMOVAL	Left rain removal SOV	Open
	Right rain removal SOV	Simulated Open
	Ejector valve	Open
Note: The windshield overheat sensor protects the windshield by shutting off BOTH rain removal SOVs during the overheat condition. It also lights the windshield hot light on the caution panel. The windshield wash system is partially inoperative because there isn't any rain removal. We can simulate a windshield overheat condition on the simulation panel.		
Windshield overheat simulation switch to > 445°F	Right rain removal SOV	Closed
	Left rain removal SOV	Closed
	Windshield hot light	ON
Rain removal switch to WASH momentarily	Right windshield wash SOV	Open 5 sec Simulated
	Left windshield wash SOV	Open 5 sec
	Ejector valve	Open 5 sec
	Right and left rain removal SOV	Closed because of windshield overheat condition
Windshield overheat switch to < 445°F	Windshield hot light	OFF

SECTION III

TROUBLESHOOTING (TRAINER)

For this part of the project you will be given five malfunctions to troubleshoot in lab 109. Of the five troubles given, you must locate four of them correctly. Tell the instructor you are now ready to troubleshoot. He will give you an AFTO Form 781A which lists five malfunctions. Put a trouble switch to the ON position and troubleshoot until you find the malfunction. Complete the 781A by listing the corrective action and making all other entries as required.

Environmental/Pneudraulic Branch
Chanute AFB, Illinois

C3ABR42331-WB-311A
2 July 1982

FIGHTER/BOMBER WINDSHIELD CLEARING SYSTEM

OBJECTIVE

Using a wiring diagram, specify eight of ten causes for system malfunctions in the fighter bomber windshield clearing system.

PROCEDURE

Turn to foldout 1. This is the wiring diagram of the windshield clearing system. Use the colored pencils and the instructions given in each step to trace the circuits. Foldout 1 will be used for each step in the project.

Step 1

Use a red pencil to trace the following circuits. Start at CB10, and trace wire H401A22 to pin H on the control panel. From there, trace the wire to junction U. At junction U the circuit parallels to 4 on the right windshield selector switch and to X1 of the XK1 relay. This is the CB10 circuit. Start at CB11 and trace wire H402A22 to pin J on the control panel. From there, trace the wire to 3 on the left of the windshield selector switch, and stop. This is the CB11 circuit. Start at CB12 and trace wire H400A22 to pin A of the windshield overheat thermal switch. Go to CB12 again and trace wire H400B22 to pin K of the control panel. From there, trace this wire to A2 of the XK2 relay. This completes the main "power" circuits (CB10, CB11, CB12).

Step 2

The reason for not tracing to the coil of the XK1 relay is because the coil does not normally have a ground. XK1 relay has a ground just when the TD relay is energized. This ground wire goes to the relay and is hooked to a box marked TD. Another wire comes out of this box and then goes to F2. TD is for "TIME DELAY". The "TIME DELAY" circuit is just closed for 5 seconds. For the time this circuit is in operation, the switch below the coil is pulled to the right to make a circuit through the coil to X2 and then to ground. This action will make a ground for the coil. The power that was

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RGL: N/A

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at X1 now has a ground and will energize the coil that will draw the upper contacts down. After 5 seconds the switch moves to its original position and again the coil has no ground. The contacts above the coil will also move back to their original positions. This 5 second delay is used to control the windshield wash cycle.

Step 3

The next circuit is for rain removal action over both windshields. Use a blue pencil to trace this circuit. The power circuits have already been traced to 3 and 4 of the windshield selector switch. Trace from 3 through the switch to the wire junction. From the junction trace to the right of A2 and B2 of relay XK1. Relay XK1 is deenergized. Go back to the junction and trace to the left and to the next junction. From this junction follow the wire through the coil of relay XK3. Show the contacts energized. From the last junction traced, go to the left and show power at the lower contact of the windshield and rain removal switch. The rain removal switch has been placed to RAIN REMOVE. Power goes through the lower switch to the upper contact and then to the second junction. From this junction, power goes to the left to contact A1. Keep in mind, XK3 relay has been energized, so draw in the circuit from A1 to A2. From there, trace to the bleed air ejector valve and then to ground. Return to the junction connected to A1. Go up a little, to find another junction. From here trace power to B2 of relay XK2. Since this relay is not energized, trace power to B3 of relay XK2 and then to P of the control panel. From here trace power to the right rain removal shutoff valve and then to ground. The right rain removal shutoff valve is now open.

Step 4

The circuit through the left windshield selector switch has been drawn. Trace power from 4 on the right windshield selector switch to the wire junction. Go to the right and show power at switches C2 and D2 of the XK1 relay. Go back to the junction and trace to the left and to the upper contact of the rain removal switch. The rain removal switch is in RAIN REMOVE, so trace to the upper contact. From here trace to the first junction and down to the next junction. From here to the right and to the left rain removal shutoff valves, and then to ground. The left rain removal shutoff valve is now open. This completes the entire circuit when the rain removal switch is placed to RAIN REMOVE and the windshield selector switch is placed to BOTH.

Step 5

The following circuit will show how both windshields are washed. Use a GREEN pencil to trace this circuit. The power circuits (in red) have been traced to 3 and 4 of the windshield selector switch. Start at 3 of the left switch, trace to the wire junction. From the wire junction, go to the right and show power at A2 and B2 of the XK1 relay. Go to the left of the junction to the next junction. From this point, trace the wire that goes down. Trace it to the coil of the XK3 relay and then to ground. Draw the contacts down. Go back

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to the last junction and continue to the left to the windshield wash and rain removal switch. For the circuit to wash both windshields, trace from the lower switch to the lower contact, from the lower contact to B1 of the XK3 relay. This relay is energized. Trace from B1 to B2 of the XK3 relay. From XK3 relay to F2 of the XK1 relay. Keep in mind what the TD represents. If not, go back and refresh your memory. From F2 of XK1, power will go in the box marked TD, then out the other side to X2 and then to ground. This is the time delay circuit that holds for 5 seconds. Circuit power can now go from X1 of the XK1 relay through the coil to ground. This action energizes the XK1 relay.

Step 6

With the XK1 relay energized, the contacts are forced down. Power that is at A2 and B2 can now cause current to flow. Trace from A2 to A1 and from A1 to M of the control panel, then to the right windshield wash shutoff valve and to ground. Trace from B2 to B1 of the XK1 relay, then from B1 to the first junction. From the junction trace to the left to A1 of the XK3 relay. This relay is energized. Go from A1 to A2 to G of the control panel. From G, trace to the bleed air ejector valve then to ground. Go back to the last junction that led to A1 of the XK3 relay. From here go up to the next junction. From this junction go to the right to B2 of the XK2 relay. This relay is not energized. Go from B2 to B3 then on to P of the control panel. From P of the control panel, trace to the right rain removal shutoff valve then to ground. This completes the circuit just for the right side.

Step 7

Now trace the circuit that will show operation of the left side of the rain removal system. Start at 4 and trace through the right switch, down to the first junction. From the junction go down to C2 and D2 of the XK1 relay. The coil of this relay is energized. Trace from C2 to C1 and to the next junction. From this junction go to the right to C2 of the XK2 relay. This relay is not energized. Trace from C2 to C3 then to N of the control panel. From N, trace to the rain removal shutoff valve and to ground. Go back to D2 of the XK1 relay and trace from D2 to D1 and then to L of the control panel. From L, trace to the left windshield wash shutoff valve. This circuit is now complete. Both windshields are now being washed. Keep in mind, the time delay (TD) of the XK1 relay is just for 5 seconds. When this time is up, the coil of the XK1 will not have a ground. With no ground the relay deenergizes and pushes the contacts up. This action: (a) closes the right windshield wash shutoff valve; (b) closes the right rain removal shutoff valve; (c) closes the left rain removal shutoff valve and (d) closes the left windshield wash shutoff valve.

Step 8

Both the windshield wash and the windshield rain removal systems are on the wiring diagram. The last circuit that will be shown is the windshield overheat circuit. Use a black pencil for this circuit. If the temperature of the air is more than 445°F, due to too much hot air in the supply system, then the normally open windshield overheat thermal switch will close. This action will make a circuit from B of the overheat switch to the coil of XK2 relay. When this happens the contacts are pulled down. This breaks the circuit to the right rain removal valve at B3 of the XK2 relay. Energizing this relay will also cut power to the left rain removal shutoff valve. The energized relay will also complete a circuit from A2 to A1 of the XK2 relay, to the WINDSHIELD HOT caution light in the cockpit. When the temperature of the air is less then 445°F, the thermal switch opens. The system returns to normal operation.

Step 9

There are 10 circled numbers on foldout 1 that indicate opens or shorts in a circuit. Below are 10 statements of troubles in the windshield clearing system. Read the statement and select the trouble number that could cause the conditions given.

1.__________. Windshield wash system inoperative.

2.__________. Left rain removal shutoff valve and bleed air ejector valve will not work when left rain removal is selected.

3.__________. Bleed air ejector will not work in left rain removal.

4.__________. Left windshield wash valve inoperative.

5.__________. Windshield hot light will not work in an overheat condition.

6.__________. Rain removal system is inoperative and hot light remains on at all times.

7.__________. Bleed air ejector valve and right rain removal shutoff valve remain closed when wash is selected.

8.__________. Rain removal shutoff valves remain open during overheat and windshield hot light will not illuminate.

9.__________. Left rain removal shutoff valve and bleed air ejector valve will not work when left windshield wash is selected.

10.__________. Time delay relay is inoperative during right windshield wash.

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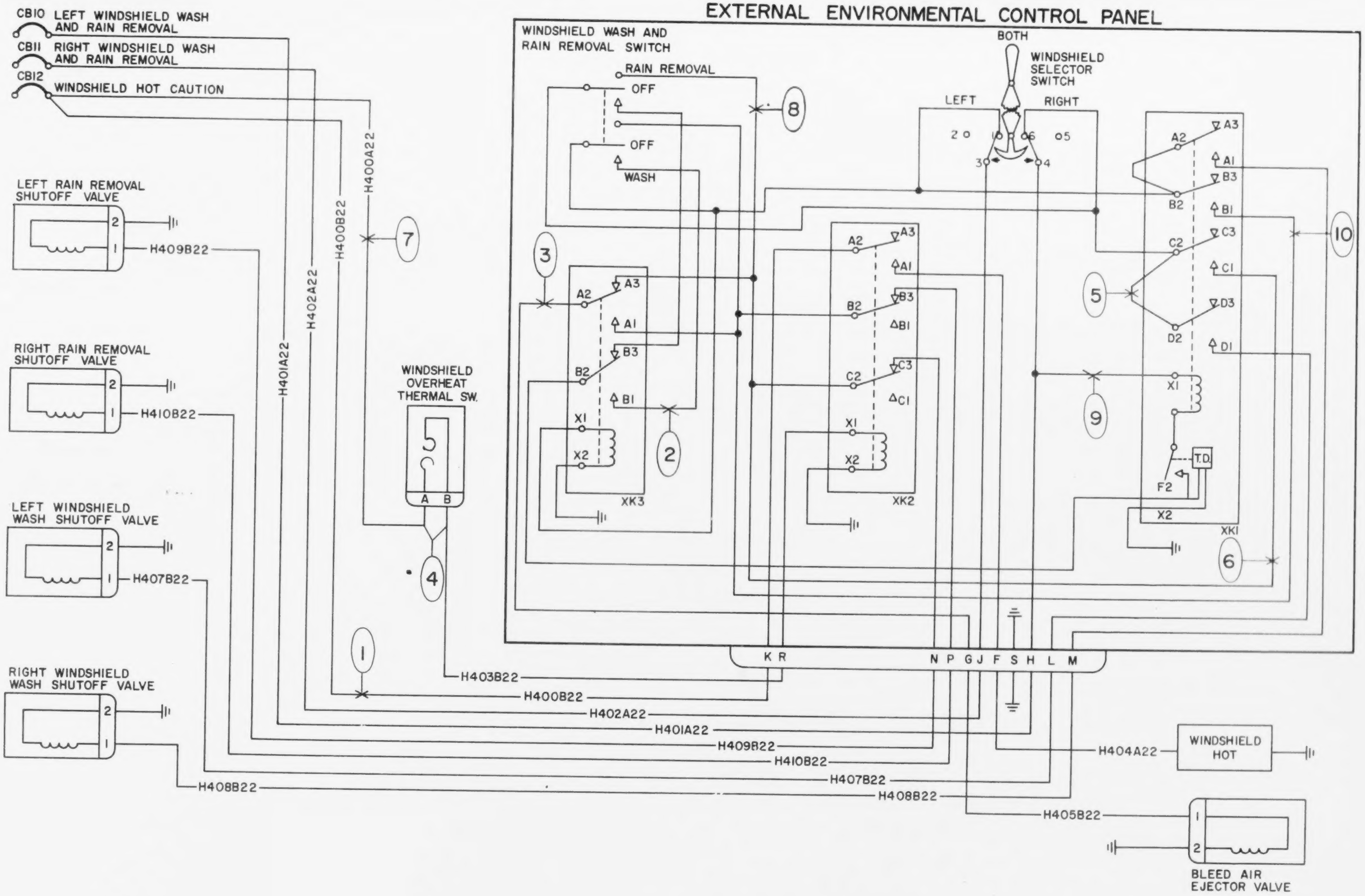
EXTERNAL ENVIRONMENTAL CONTROL PANEL
CB10 LEFT WINDSHIELD WASH AND RAIN REMOVAL
CB11 RIGHT WINDSHIELD WASH AND RAIN REMOVAL
CB12 WINDSHIELD HOT CAUTION
LEFT RAIN REMOVAL SHUTOFF VALVE
RIGHT RAIN REMOVAL SHUTOFF VALVE
LEFT WINDSHIELD WASH SHUTOFF VALVE
RIGHT WINDSHIELD WASH SHUTOFF VALVE
WINDSHIELD OVERHEAT THERMAL SW.
A B
WINDSHIELD WASH AND RAIN REMOVAL SWITCH
RAIN REMOVAL
OFF
OFF
WASH
BOTH
WINDSHIELD SELECTOR SWITCH
LEFT
RIGHT
1 2 3 4 5 6
A1 A2 A3 B1 B2 B3 C1 C2 C3 D1 D2 D3 X1 X2
XK1
XK2
XK3
T.D.
F2
K R N P G J F S H L M
H400A22
H400B22
H401A22
H402A22
H403B22
H404A22
H405B22
H407B22
H408B22
H409B22
H410B22
1
2
3
4
5
6
7
8
9
10
WINDSHIELD HOT
BLEED AIR EJECTOR VALVE

Foldout 1.
5

PROGRAMMED TEXT
C3ABR42331-PT-312

Technical Training

Aircraft Environmental Systems Mechanic

AIR CONTROL VALVES

23 April 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 8.9

OBJECTIVE

Relate the components of Air Control units to their operation with 80% accuracy.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After reading each frame, you are expected to respond by choosing either TRUE or FALSE. DO NOT MARK IN THIS TEXT.

Read the material presented, select your response to the question, and indicate your response on the response sheets. After you respond to the question, compare your answer with the one given on the top of the next frame. If your answer is wrong, read the frame again.

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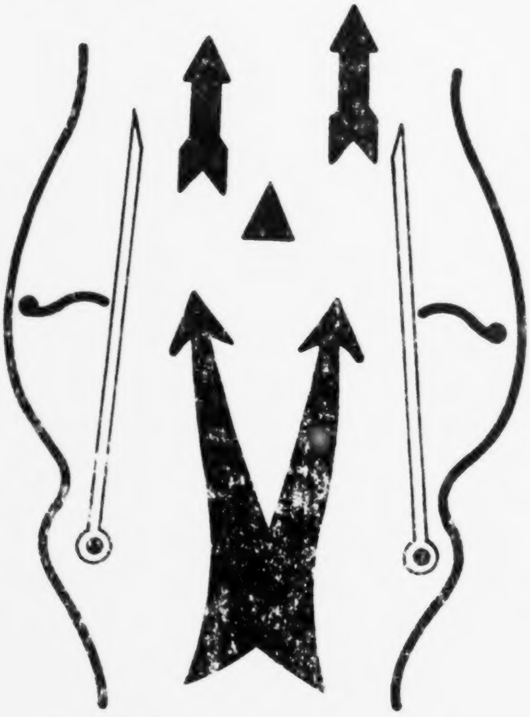
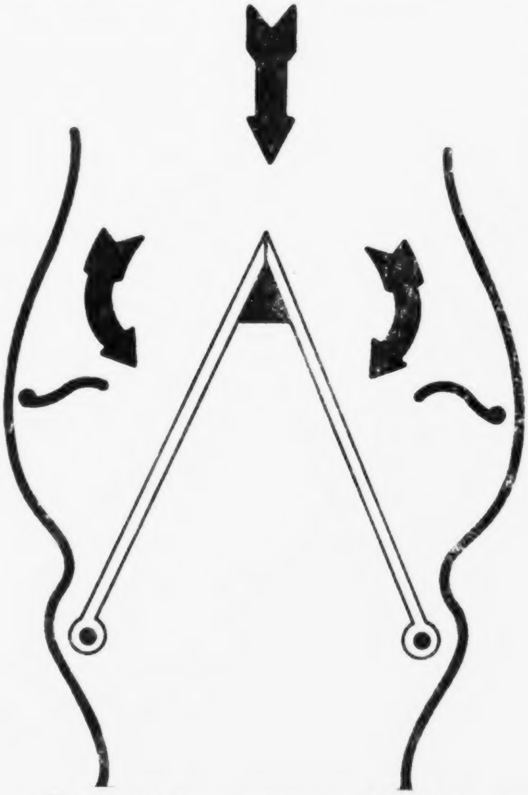
The three main types of air control valves that are discussed in this text are air check valves, electric motor operated valves, and pneumatic actuated valves.

Let's first look at the air check valves. They vary in size from about one inch in diameter (used in small air lines) to 5 inches in diameter used in air supply lines. However, no matter how large or small the check valves are, they all are used for the same purpose. They prevent the reverse flow of air. In other words, they allow air to flow in one direction only. There is an arrow (→) on the valve housing to show you which direction to install the valve. Always install the valve with the arrow pointing in the direction of airflow.

You can see what would happen if the check valve was installed in the system the wrong way. That's right--no airflow.



Check Valve - Normal Airflow.



Check Valve - Reverse Airflow.

Note: Determine which of the following statement(s) are true and which are false.

1. The purpose of the check valve is to prevent reverse flow of air.

2. Always install the valve with the arrow in the direction of airflow.

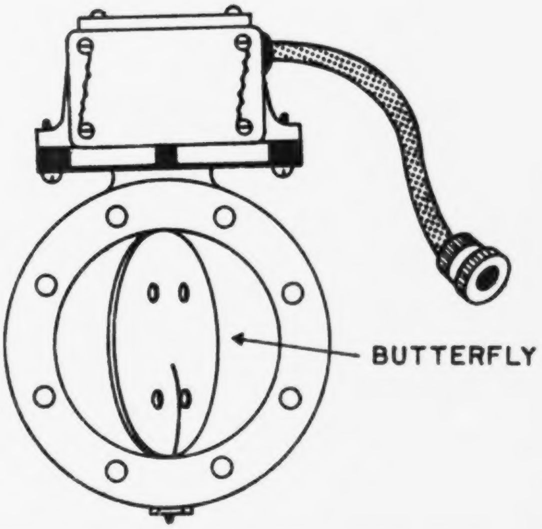
3. It doesn't matter which way a check valve is installed in the system.

4. No matter how large a check valve is, it has the same purpose as a small one.

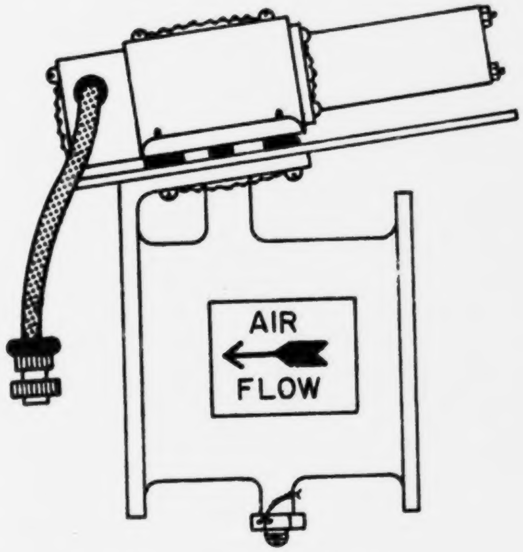
CORRECT RESPONSES TO FRAME 1: 1. T 2. T 3. F 4. T.

Frame 2

We will now look at electric motor actuated valves. These valves are of different types and are used for different systems. Some different types of electric motor actuated valves are the butterfly, spoon and sliding gate. All these valves are driven by an electric motor. As environmental systems repairmen we are mainly concerned with the butterfly type valve. The butterfly valves can start and stop airflow, such as a shutoff valve. They are also used to slow airflow, such as a modulating valve. Modulating valves can be stopped anywhere between full open or full closed.



Internal View, Butterfly Valve Open



External View of Valve.

Electric Motor Actuated Valve.

Note: Determine which of the following statement(s) are true and which are false.

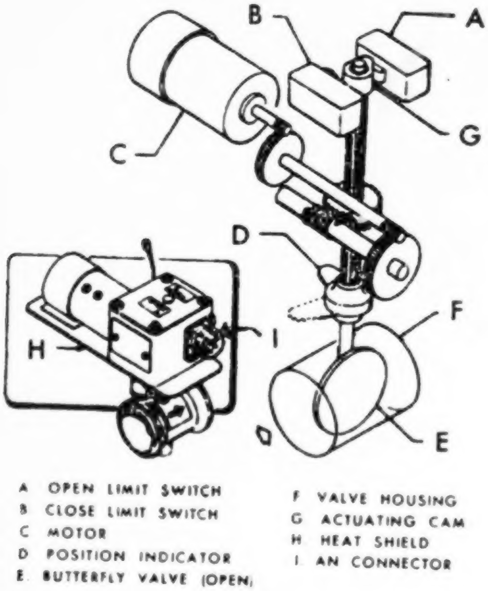
1. Electric motor actuated valves cannot be stopped between full open and full closed.

2. Shutoff valves are used to start and stop airflow.

3. Electric motor actuated valves can operate various types of valves.

4. Modulating valves can be stopped anywhere between full open and full closed position.

Let's take a look at the power requirements of some of the electric motor actuated valves. The electrical power used by most of the valves is either 28 volts DC; 115 volts AC, 400 Hertz, single phase; or 230 volts AC, 400 Hertz, three phase. You can see there are valves with various voltages. One way you can find out what electrical power a valve needs is to look on the data plate attached to the valve. If the information is not on the data plate look in the technical order for the valve. The parts of **a typical valve are identified** in the illustration.


A
B
C
D
E
F
G
H
I
A OPEN LIMIT SWITCH
B CLOSE LIMIT SWITCH
C MOTOR
D POSITION INDICATOR
E BUTTERFLY VALVE (OPEN)
F VALVE HOUSING
G ACTUATING CAM
H HEAT SHIELD
I AN CONNECTOR

Electric Motor Actuated Butterfly Valve.

Note: Determine which of the following statement(s) are true and which are false.

1. There are several voltages that can be used for power in electric motor actuated valves.

2. There is only one limit switch in each motor actuator.

3. Another name for a motor is an actuator.

4. Power requirements for valves can be found in technical orders.

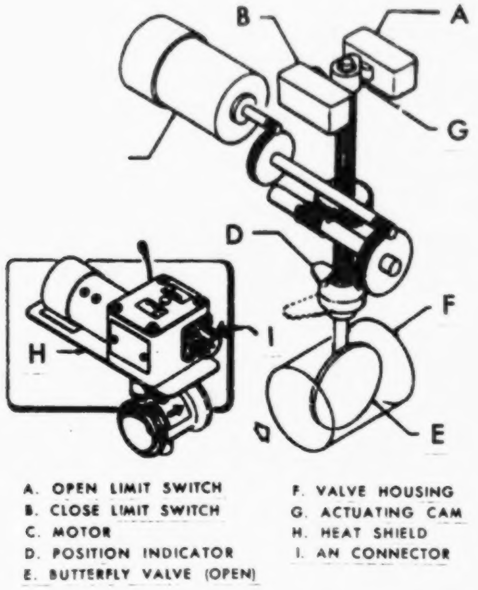
CORRECT RESPONSES TO FRAME 2: 1. F 2. T 3. T 4. T.

CORRECT RESPONSES TO FRAME 3: 1. T 2. F 3. T 4. T.

Frame 4

Let's go into the function of the parts of an electric motor actuated valve. Follow the diagram below as you go along.

The motor (c) is used to drive the gear train. The gear train drives the actuating cam (g) and position indicator (d). The actuating cam contacts the limit switches. Limit switch (a) stops the motor when the butterfly valve (e) is in the full open position. Limit switch (b) stops the motor when the buterfly valve is in the full closed position. The gear train is used to increase torque of the motor. The position indicator is used to save you time as a mechanic. It tells you at a glance what position the butterfly valve is in, without having to remove it from the aircraft.


B
A
G
D
F
I
H
E
A. OPEN LIMIT SWITCH
B. CLOSE LIMIT SWITCH
C. MOTOR
D. POSITION INDICATOR
E. BUTTERFLY VALVE (OPEN)
F. VALVE HOUSING
G. ACTUATING CAM
H. HEAT SHIELD
I. AN CONNECTOR

Electric Motor Actuated Valve.

Note: Determine which of the following statement(s) are true and which are false.

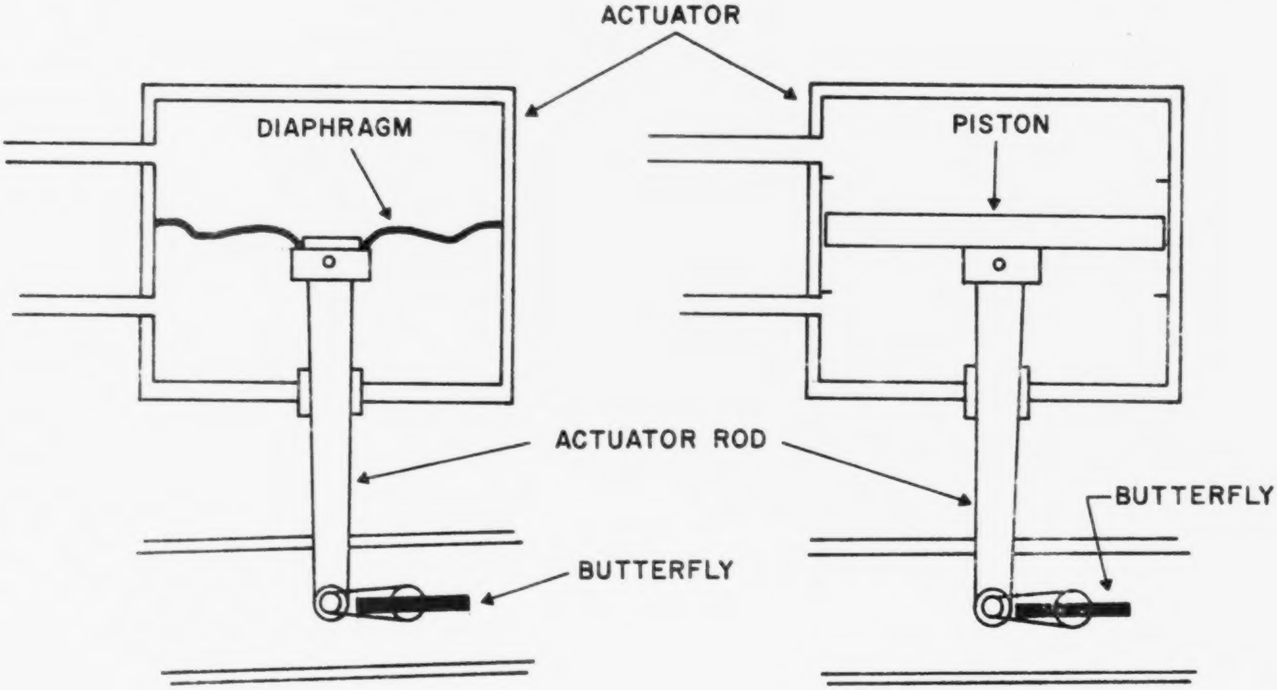
1. The motor drives the gear train, actuating cam, and position indicator.

2. Both limit switches are contacted at the same time.

3. The gear train increases the torque of the motor.

4. The mechanic can tell what position the butterfly valve is in by looking at the position indicator.

Pneumatic actuated valves are actuated by air. There are two main types of pneumatic actuated valves; piston or diaphragm operated. These valves are used in the bleed air system to control airflow. The two major components are the actuator and the butterfly. A fail-safe system is built into the valve. Fail-safe means the valve would return to the original position (open or closed), if electrical power or system pressure failed. Next we will discuss valve controlling devices.



Diaphragm Actuated Valve

Piston Actuated Valve

Note: Determine which of the following statement(s) are true and which are false.

1. Pneumatic actuated means air actuated.

2. All valves are fail-safe closed.

3. Piston type valves are electrically operated.

CORRECT RESPONSES TO FRAME 4: 1. T 2. F 3. T 4. T.

CORRECT RESPONSES TO FRAME 5: 1. T 2. F 3. F.

Frame 6

Controlling devices for pneumatic valves consist of: (1) solenoids, (2) thermostats, (3) pneumatic relays, or (4) pressure switches which control the position of the valve.

1. The solenoid controls air pressure to open or close a valve by allowing air pressure to stop or pass through the solenoid.

2. The pneumatic thermostats are controlled by temperature which either open or close a small bleed port, controlling the buildup or release of pressure acting on the diaphragm of a pneumatic valve.

3. The pneumatic relays are used in the pressurization system to prevent lag time between the controller and outflow valves, when the outflow valves are located a considerable distance between units.

4. The pressure switches are used in conjunction with a valve that operates under a pregiven pressure similar to an aneroid switch. Most pressure switches operate in conjunction with a pneumatic thermostat.

Note: Determine which of the following statement(s) are true and which are false.

1. Pneumatic thermostats are controlled by air pressure.

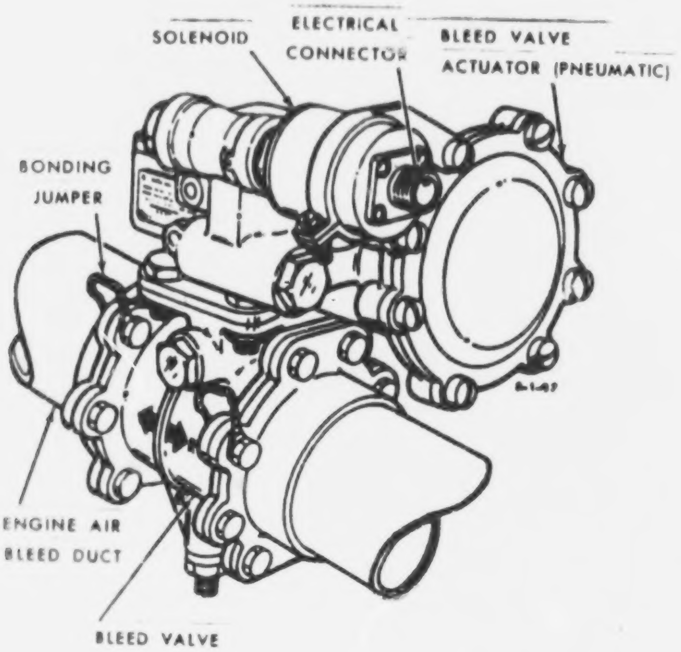
2. Lag time between the controller and outflow valves is controlled through a pneumatic relay.

3. All pressure switches work in conjunction with a pneumatic thermostat.

4. A solenoid is a controlling device.

Frame 7

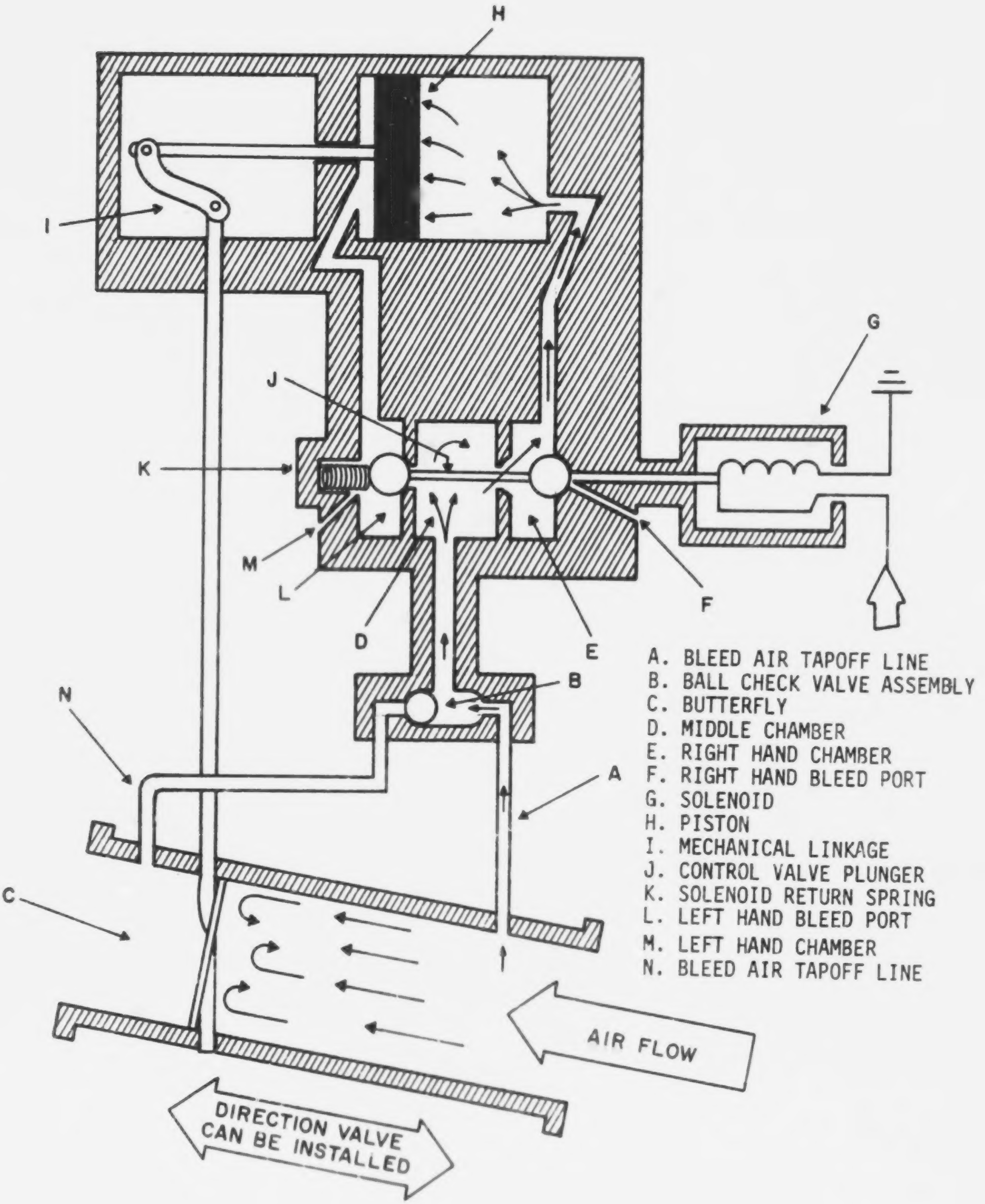
Types of Pneumatic Valves. The piston-actuated valve has a piston similar to the one in a car. Instead of steel rings, rubber "O" ring seals are used. The piston rod is connected to a mechanical linkage. The linkage is attached to the butterfly valve. When air pressure is applied to the top or bottom of the piston, the valve will open or close. Normal opening or closing time is approximately one second for all valves. A piston actuator is normally controlled by a solenoid valve. A solenoid valve is sometimes referred to as a switcher valve. It switches the air pressure either to the top or bottom of the piston. This controls the direction of piston movement.


SOLENOID
ELECTRICAL CONNECTOR
BLEED VALVE ACTUATOR (PNEUMATIC)
BONDING JUMPER
ENGINE AIR BLEED DUCT
BLEED VALVE

Pneumatic Piston Actuated Valve.

Note: Determine which of the following statement(s) are true and which are false.

1. "O" ring seals are used on piston-actuated valves.
2. Normally 1 second is required for the valve to open.
3. A switcher valve controls the mechanical linkage.


H
I
J
G
K
M
L
D
E
F
B
N
A
C
AIR FLOW
DIRECTION VALVE CAN BE INSTALLED

A. BLEED AIR TAPOFF LINE
B. BALL CHECK VALVE ASSEMBLY
C. BUTTERFLY
D. MIDDLE CHAMBER
E. RIGHT HAND CHAMBER
F. RIGHT HAND BLEED PORT
G. SOLENOID
H. PISTON
I. MECHANICAL LINKAGE
J. CONTROL VALVE PLUNGER
K. SOLENOID RETURN SPRING
L. LEFT HAND BLEED PORT
M. LEFT HAND CHAMBER
N. BLEED AIR TAPOFF LINE

Pneumatic Piston Actuated Valve (De-energized Closed).

CORRECT RESPONSES TO FRAME 6: 1. F 2. T 3. F 4. T.

CORRECT RESPONSES TO FRAME 7: 1. T 2. T 3. T.

Frame 8

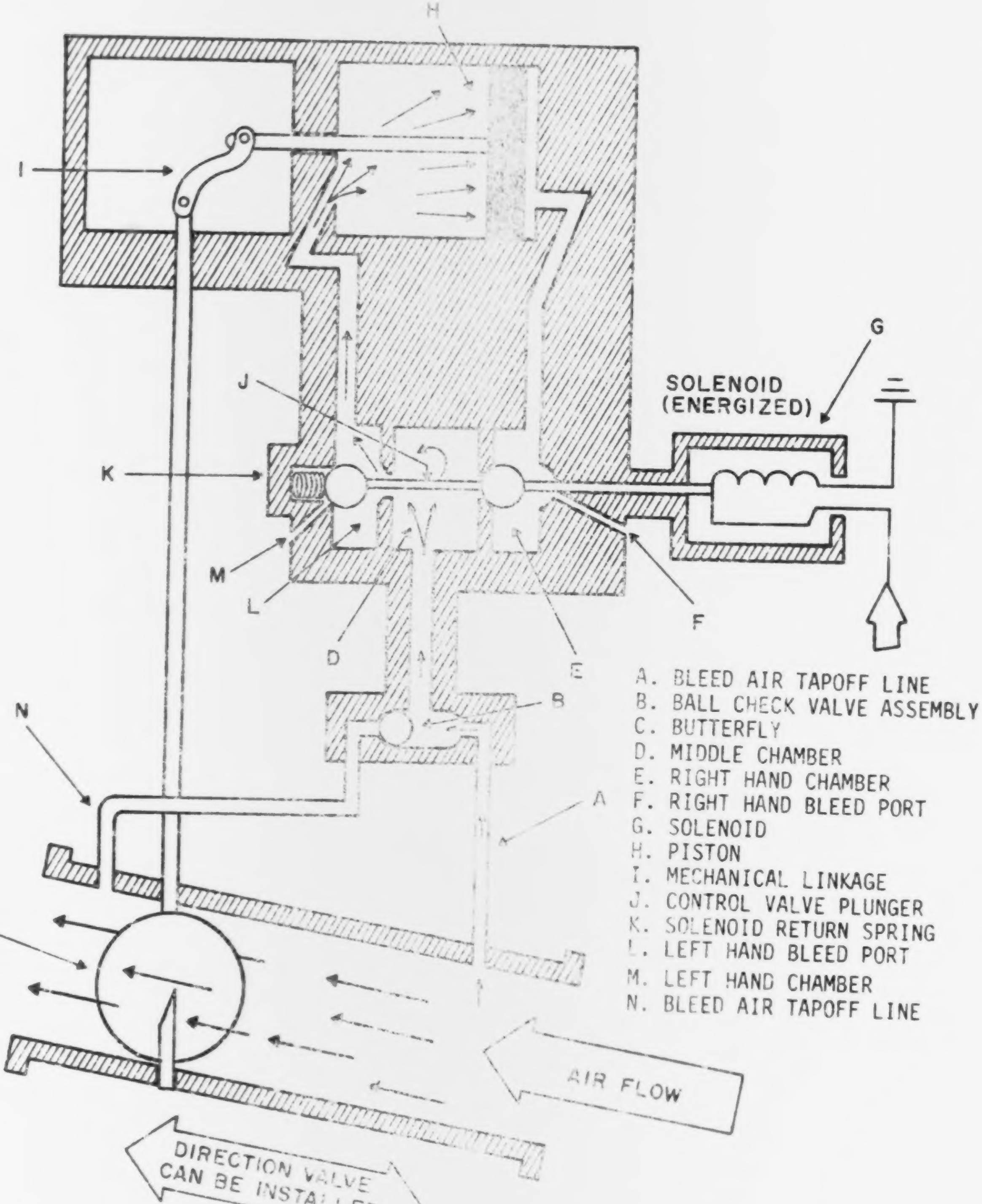
Operation of the Pneumatic Piston Actuated Valve. Refer to the illustration of the valve on page 10. Air pressure is tapped from the body of the valve through (a or n) either side of the butterfly (c). Airflow is then routed to the shuttle valve (b). The shuttle valve prevents air pressure from escaping to the opposite side of the butterfly. The shuttle valve directs air pressure to the middle chamber (d). At this point the air will be controlled by the solenoid (g). The direction of the air movement will depend on the position of the solenoid. When the solenoid is de-energized air will pass into the right hand chamber (e). From the right chamber air flows up the passageway to the top of the piston (h). Air pressure forces the piston to the left. Through mechanical linkage, the butterfly (c) will be held closed.

Note: Determine which of the following statement(s) are true and which are false.

1. Air is trapped from either side of the butterfly.

2. The direction of airflow depends on the check valve position.

3. A de-energized solenoid will cause the valve to close.


H
I
G
SOLENOID (ENERGIZED)
J
K
M
L
D
E
F
N
B
A
C
AIR FLOW
DIRECTION VALVE CAN BE INSTALLED

A. BLEED AIR TAPOFF LINE
B. BALL CHECK VALVE ASSEMBLY
C. BUTTERFLY
D. MIDDLE CHAMBER
E. RIGHT HAND CHAMBER
F. RIGHT HAND BLEED PORT
G. SOLENOID
H. PISTON
I. MECHANICAL LINKAGE
J. CONTROL VALVE PLUNGER
K. SOLENOID RETURN SPRING
L. LEFT HAND BLEED PORT
M. LEFT HAND CHAMBER
N. BLEED AIR TAPOFF LINE

Pneumatic Piston Actuated Valve (Energized Open).

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CORRECT RESPONSES TO FRAME 8: 1. T 2. F 3. T.

Frame 9

Refer to the illustration on page 12. To open the valve, 28 volt DC is applied to the solenoid valve (g), energizing the solenoid. This action causes the control valve plunger (j) to move to the left. The plunger closes the air inlet port of the right hand chamber (d). The right hand bleed port (f) is now opened Air from the top of the piston is vented overboard. With the solenoid energized, the left hand bleed port (1) is closed. The left hand chamber (m) inlet port is open. This allows pressure to be applied to the bottom of the piston. The piston (h) will be forced to the right moving the mechanical linkage and opening the valve. Air can then flow through the valve (o). To close the valve, de-energize the solenoid (g). The solenoid return spring (k) will move the control valve plunger to the right. Air pressure is directed to the top of the piston, closing the valve. Air is vented from the bottom of the piston through the left hand bleed port (1). Port leakage past the butterfly is compensated by adjusting the mechanical linkage of the valve.

Note: Determine which of the following statement(s) are true and which are false.

1. Air directed to the bottom of the piston will open the valve.

2. Bleed ports are used to bleed the air from the top and bottom of the piston.

3. The solenoid is energized to open the butterfly.

CORRECT RESPONSES TO FRAME 9: 1. F 2. T 3. T.

Frame 10

Diaphragm Actuated Valves. A diaphragm actuated valve is similar to a piston actuator with the exception of a piston; a diaphragm is used instead. A diaphragm is a canvas cloth impregnated and coated with rubber. This prevents air from passing through it. However it is flexible enough to allow movement. The diaphragm separates two chambers. One chamber is normally vented to the atmosphere. The other has a spring to load the butterfly valve to the open or closed position. Some valves have the spring on the pressure side, but these are exceptions to the rule. The other chamber of the actuator is connected to a pressure source. Attached to the diaphragm is a rod. The rod is connected to the mechanical linkage of the butterfly shaft.

Note: Determine which of the following statement(s) are true and which are false.

1. A diaphragm is very flexible.

2. The diaphragm actuator rod is connected to a mechanical linkage.

3. The valve could be spring loaded to the open and closed position.

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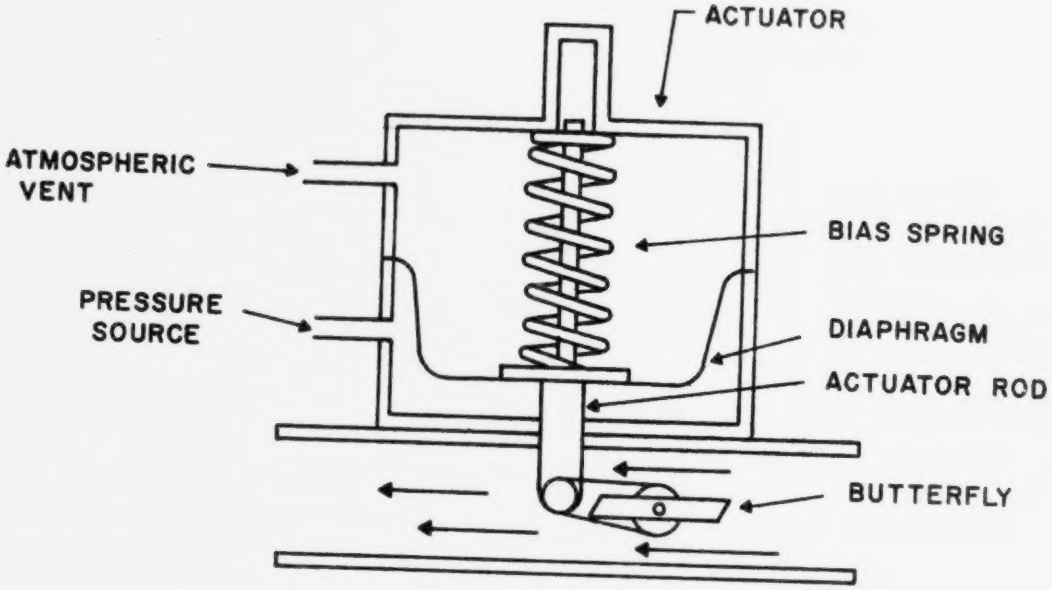
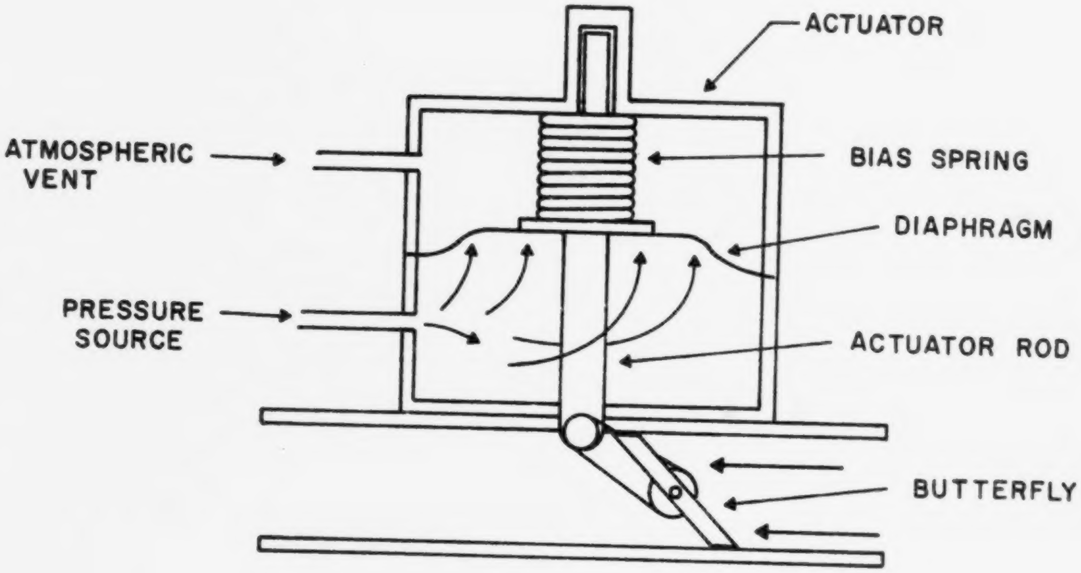

ACTUATOR
ATMOSPHERIC VENT
BIAS SPRING
PRESSURE SOURCE
DIAPHRAGM
ACTUATOR ROD
BUTTERFLY

Diaphragm Actuated Valve (Spring Loaded Open).


ACTUATOR
ATMOSPHERIC VENT
BIAS SPRING
DIAPHRAGM
PRESSURE SOURCE
ACTUATOR ROD
BUTTERFLY

Diaphragm Actuated Valve (Spring Loaded Open)
With Air Pressure Applied to Close the Valve.

CORRECT RESPONSES TO FRAME 10: 1. T 2. T 3. F

Frame 11

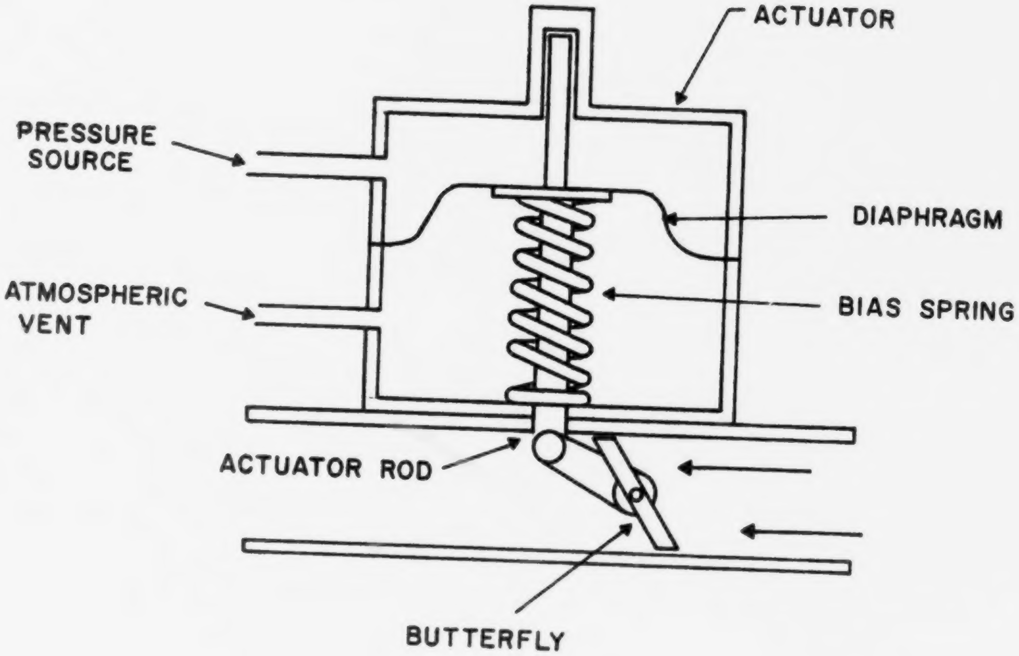
Spring Loaded Open Diaphragm Actuated Valve. Refer to the top illustration on page 16. This illustration represents a valve, spring loaded to the open position. Let's see how the valve can be controlled. With no pressure at the pressure source, the spring forces the diaphragm down. This forces the actuator rod, through mechanical linkage, to hold the butterfly open. To close the valve (bottom illustration) a predetermined pressure is applied from the pressure source. Pressure buildup will force the diaphragm upward; compressing the spring. As the diaphragm moves upward, the actuator rod, through mechanical linkage, begins to close the valve. The atmospheric pressure on top of the diaphragm is forced out the atmospheric vent. This allows free movement of the diaphragm.

Note: Determine which of the following statement(s) are true and which are false.

1. To allow free movement of the valve, one side is vented.

2. The valve on page 14 is spring-loaded closed.

3. Atmospheric air pressure is applied to actuate the valve.


ACTUATOR
PRESSURE SOURCE
DIAPHRAGM
ATMOSPHERIC VENT
BIAS SPRING
ACTUATOR ROD
BUTTERFLY

Diaphragm Actuated Valve (Spring Loaded).

CORRECT RESPONSES TO FRAME 11: 1. T 2. F 3. F.

Frame 12

Spring Loaded Closed Diaphragm Actuated Valve. Refer to illustration on page 18. The spring will push the diaphragm up, causing the actuator rod to hold the butterfly closed. When pressure is applied from the pressure source, the diaphragm will be forced down. The actuator rod moves the butterfly open.

Note: Determine which of the following statement(s) are true and which are false.

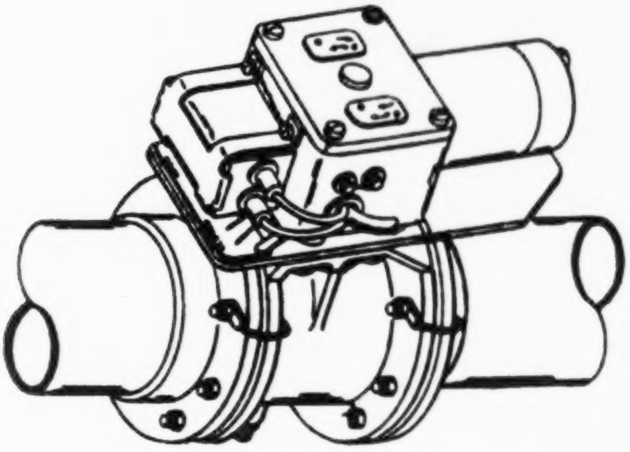
1. With the valve spring loaded to the closed position, pressure is applied to open the valve.

2. Pressure is applied to the bottom of the valve diaphragm to open the valve.

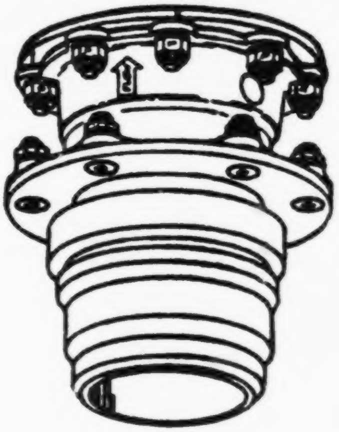
CORRECT RESPONSES TO FRAME 12: 1. T 2. T

Frame 13

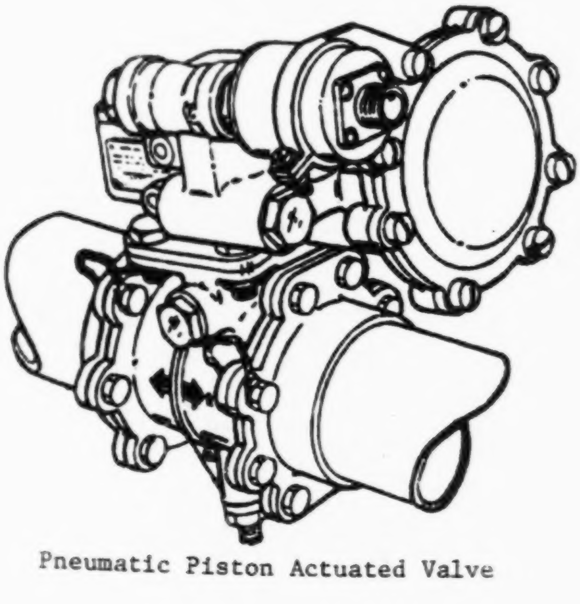
Air check valves are always installed in a system with the arrow pointing in the direction of airflow. Remember the purpose and power requirements for each type of valve discussed in the text. If in doubt, recheck the text to make sure. Now here is another look at the valves we have discussed. Remember what they look like. You will see them again.



Electric Motor Actuated Butterfly Valve



Air Check Valve



Pneumatic Piston Actuated Valve

No Response Required

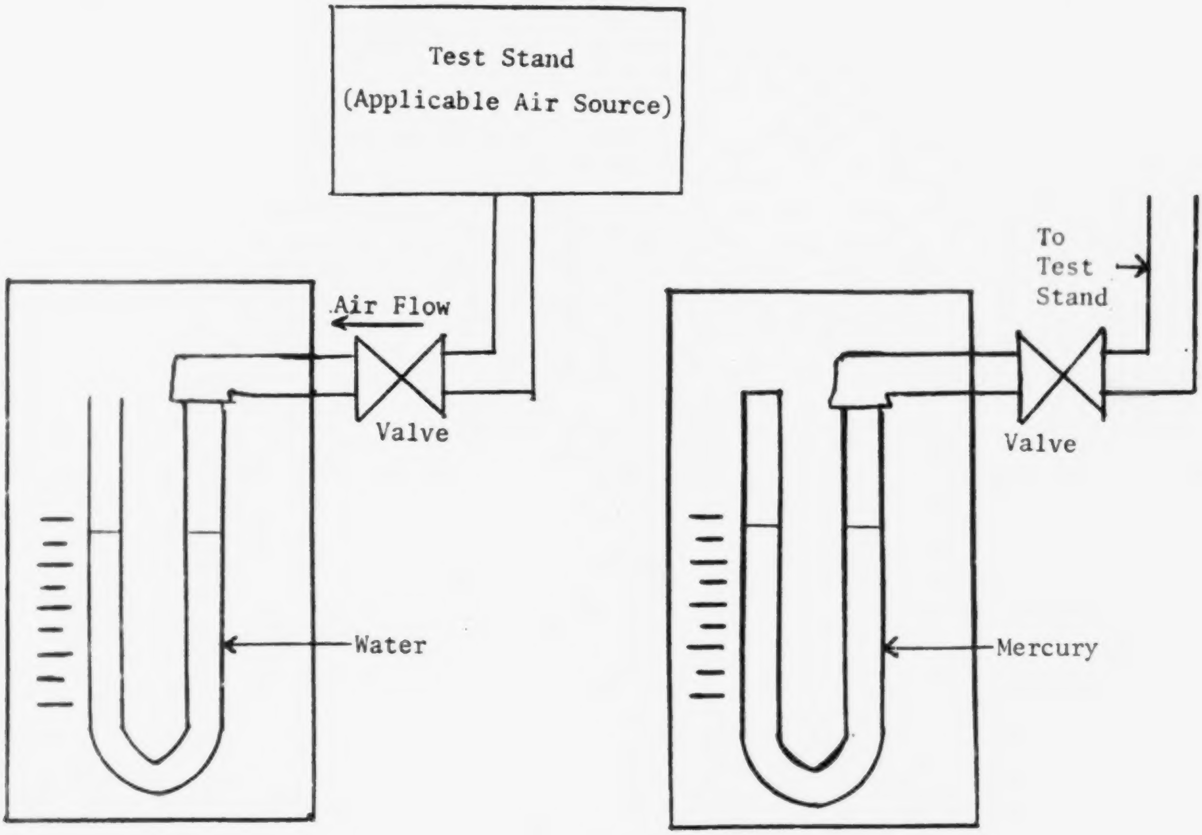
Bench testing of an air control valve can be a simple matter of just operating the valve. An operational check (not a bench check) can be performed on the aircraft. This check will allow you to determine if the valve is faulty; or the pneumatic system has failed. When a valve is not operating properly, it must be removed and sent to your shop for repairs. Not all valves are reparable at base level. Some valves must be sent to depot for repair. However, if you are authorized to repair a valve, your shop will have the equipment and TOs available. The TOs will explain how to inspect, bench test and repair the valve. Some valves may also require a special check. These checks are outlined in the Time Compliance Technical Orders (TCTO). If a valve has been in storage for an extended period of time, then all the rubber parts must be replaced. Such as; O-ring seals, gaskets and diaphragms. TO 00-20K-6 series outlines the maximum time these valves can be stored. Cure date kits (C kits) are used to repair these valves. Cure date kits include all the rubber parts needed to repair any given valve. The cure date kit has a life time storage of 3 years. After a C kit has been stored for 3 years it can no longer be used. Always check the C kit shelf date prior to using the kit. All the parts included in the C kit should be used when repairs are made to a valve.

NO RESPONSE REQUIRED

Frame 15

Next we will discuss the manometer: How it works and how it is used to make air pressure measurements.

A manometer is the instrument that an environmental mechanic uses to measure the air pressure exerted by a valve. There are two types of manometers that you might see. Both are U-shaped glass tubes that contain either water (open) or mercury (closed).



OPEN

In the open manometer the U-shaped tube is open at both ends. (Look at the figure above.) The valve to be tested is attached to one end (called an arm) of the manometer, usually by a flexible hose. If the pressure in the valve is greater than atmospheric pressure, its pressure will force the liquid to rise in the other arm of the manometer. The difference between the heights of the liquid in the two arms is a measure of the valve's excess pressure over atmospheric

CLOSED

The closed manometer contains mercury and is closed at one end. Air at atmospheric pressure is trapped inside the closed arm of the tube. When pressure greater than atmospheric pressure is applied to the open arm, the mercury rises in the closed arm, compressing the air. The applied pressure can be read from a scale on the closed arm. This type of manometer can measure higher pressures. The closed type manometer is the one most used by the environmental mechanic. You pressure. If the valve's pressure is less than atmospheric pressure, the liquid will rise in the arm of the manometer to which the pressure is applied. One of the problems with using the open manometer is that it can only be used to measure pressures that are close to atmospheric pressure because the liquid will overflow the glass tube.

should exercise extreme caution when using the manometer. It is filled with mercury which is very dangerous to your health. It is possible to break the glass tube in which the mercury is contained.

Notice, also in the figure, that the valve is attached at two places; one end is attached to the manometer by a flexible hose and the other end is attached to the test stand. The valve is hooked up so that the airflow is going toward the manometer. Once you apply the air pressure to the valve you can make your readings on the manometer's scale to see how much the valve is leaking.

Note: Determine which of the following statement(s) are true and false.

1. The closed manometer is used mostly by the environmental system mechanic.

2. The manometer is used to measure air pressure escaping from a bleed air valve.

WORKBOOK

C3ABR42331-WB-312

Technical Training

Aircraft Environmental System Mechanic

BENCH CHECK AIR CONTROL UNITS

16 February 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: N/A

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-WB-312

BENCH CHECK AIR CONTROL UNITS

OBJECTIVE

Using the applicable TO, electric/pneumatic component trainer, multimeter, and the necessary tools, bench check selected air control units with a maximum of two instructor assists for each air control unit checked.

INSTRUCTION

Note: This workbook contains practical work assignments for you to accomplish in conjunction with your study assignments. Complete each problem or work assignment in the sequence given and it will aid you in understanding and retaining the key points covered in each assignment. Failing to have the instructor check your work at the indicated points and/or failing to follow procedures could result in a performance failure and/or disciplinary action.

This workbook is in five sections. The first one explains why components are bench checked and lists the basic steps involved. Sections, two, three, and four have you check electric motor actuated valves. Section five has you bench check a two-and-one-half inch diameter pneumatic shutoff valve. The procedures that are used to complete this workbook are listed at the beginning of each section.

Section 1. BENCH CHECK PROCEDURES

1. The trainer shown in figure 1 was manufactured here at Chanute. The test machines used in the shops throughout the Air Force may not look just like this one, but they will be used for the same thing - bench checking air control units. When bench checking any valve, you must follow TO procedures. The TO will explain step-by-step how to perform electrical checks, port leakage checks, and case leakage checks. Each check is described as follows:

a. Electrical Operation - This check consists of energizing the valves with 115 volts, 400 cycle, three phase, AC current or 26 to 28 volts DC current depending on the type of valve you are checking. You will check for sticking solenoids, limit switches, and valve travel time to the full open and closed positions.

b. Port Leakage Checks - This check consists of applying air pressure to the valve with the butterfly in the full closed position. Although some leakage is normal, it will be your job to determine if the leakage is too much. The TO for each valve will show the maximum allowable leakage.

Supersedes 3ABR42331-WB-312, 10 August 1981.
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c. Case Leakage - This test cannot be performed on the trainer. However, at the end of this workbook, you will be required to answer some questions as to what case leakage is. Case leakage testing is not often done in environmental shops. All it consists of is submerging the valve in a pressurized tank and running it to the full open position. After it is in the full open position, the outlet side is capped and pressure is applied to the inlet side of the valve. If there is any leakage, it will cause pressure to build up in the tank and show on a manometer. If the leakage is excessive, you will have to make the necessary repairs at that time.

2. You will be required to use TO indexes to find the correct tech order number for each valve bench checked. In each section of this workbook, under the heading equipment, you will find the TO index number and the valve part number. Using this information, you will be able to find the correct tech order for that valve. All the indexes and overhaul tech orders are located in the tech order file.

QUESTIONS

1. When performing the electrical operation bench check, what components are you checking? ____________________

____

2. During a port leakage check if you find that the valve is leaking, where would you find the maximum allowable leakage? ______

____

3. During a port leakage check, what is the position of the valve butterfly? ____________________

4. In the space provided below, explain briefly the three most common bench checks.

a. Case Leakage - ____________________

____

____

b. Electrical Operation - ____________________

____

____

c. Port Leakage - ____________________

____

____

Note: Have the lab instructor check your answers.

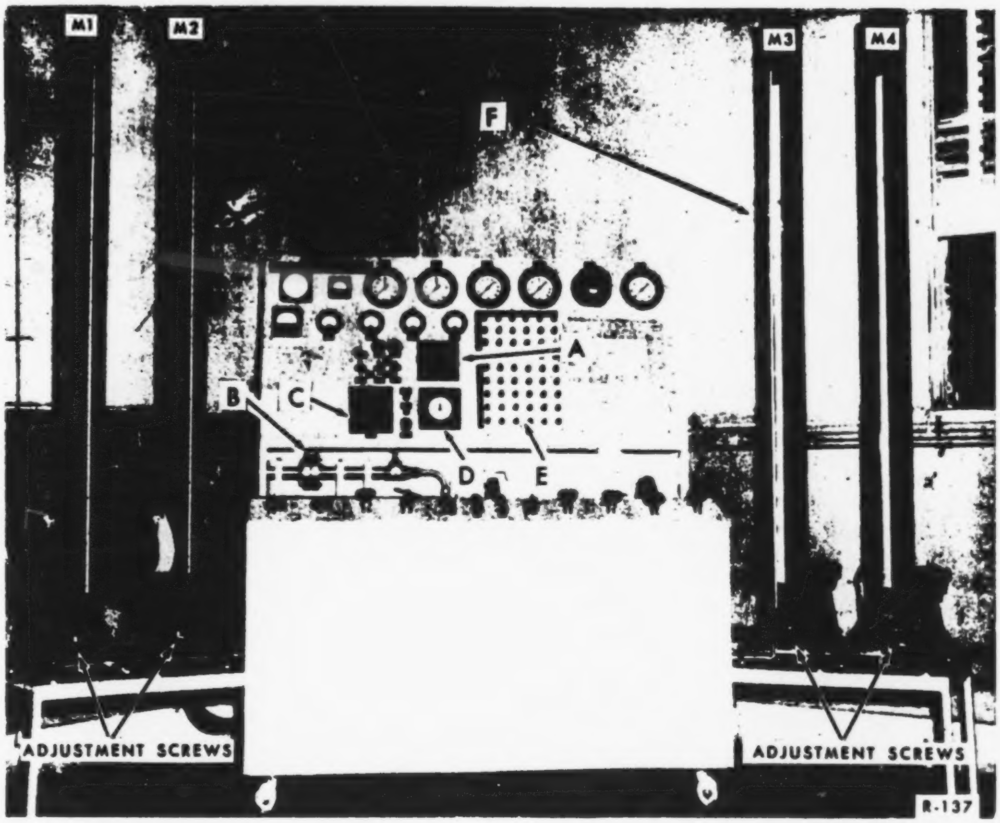
Section 2. CONTROL VALVE: BENCH CHECK OF TWO-AND-ONE-HALF INCH DIAMETER MODULATING ELECTRIC AIR SHUTOFF VALVE

EQUIPMENT

Electrical pneumatic trainer number 3038
Valve part number 104248-3
TO 9P5-14-3-3

PROCEDURE

1. Use trainer number 3038 to make a port leakage test of an electric air shutoff valve. This check is to find how much air leaks past the valve butterfly when it is in the closed position. Use figure 1 to find the following items and familiarize yourself with the trainer.



A. Voltage Adjustment Potentiometer
B. Low Capacity Flowmeter
C. Electrical Patching Panel
D. Precision Timer
E. Pneumatic Patching Panel
F. Manometers

Figure 1. Trainer Number 3038 - Electric Pneumatic Timer.

a. Voltage adjustment potentiometer (A). This unit adjusts the DC voltage on the trainer.

b. Low capacity orifice flowmeter (B). An orifice is put in this part of the trainer to keep a differential pressure at the manometers.

c. Electrical patching panel (C). Electrical wires will be hooked from this panel to the valve under test.

d. Precision timer (D). Times the cycling time of this unit under test. Press down on the black lever to reset before each test.

e. Pneumatic patching panel (E). Hoses will be hooked from this panel to the valve under test.

f. Manometers (F). These are pressure measuring devices and will be taught later.

Caution: At this point make sure that you have removed your jewelry.

2. Go to equipment locker number 2 and get a shutoff valve, Part Number 104248-3.

3. Sign out TO 9P5-14-3-3 from the TO file.

a. In the TO find the operating specifications for valve, Part Number 104248-3, and complete the following statements:

(1) Operating inlet air pressure is ________________.

(2) Operating voltage is ________________________.

(3) Operating current (amperage draw) is ____________ ________________.

(4) Cycling time open to close is ________________.

(5) Cycling time close to open is ________________.

b. Visually inspect the valve for the following:

(1) Corrosion on the housing.

(2) Cracked valve housing.

(3) Damaged threads on the cannon plug.

QUESTION

What does the TO say about removing minor nicks, scratches, burrs and mild corrosion from steel parts? ________________________ ____.

4. Trainer Preparation

a. Make sure that each switch is in the OFF position. Switch S-5 does not have to be moved at this time.

b. Plug the trainer power cables into the proper wall receptacles. Make sure that all circuit breakers on the left end of the trainer are pushed in.

5. Electrical Hookup

a. Follow the hookup shown in foldout 1 near the end of this workbook.

b. Hook the connector plug of the valve to the correct electrical pins on the trainer electrical patching panel.

c. Use the trainer wires to make these connections.

Caution: At this point check the connections before you go to the next step. This prevents the danger of a short circuit due to crossed wires. Have the instructor check your hookup.

6. Operation of the Valve

a. Place switch S-1 to the ON position. This turns on the power to the trainer. Place switch Ø SEL (phase selector) to 1Ø. The AC voltmeter should show 110 to 120 volts. The DC voltmeter should show 24 to 28 volts. If you do not have these readings, recheck your hookup and/or the voltage adjustment potentiometer (see (A) in figure 1). The potentiometer should be set to full increase.

b. Check the valve position to find if the valve is opened or closed.

(1) If the valve is open, place switch S-5 to the CLOSE position. The valve should close.

(2) If the valve is closed, place switch S-5 to the OPEN position. The valve should open.

c. Complete the following statements. First put the valve in position to make the check. Take the readings from the correct meters or gages on the trainer.

Note: Reset the timer before operating the valve.

(1) Place switch S-5 to the OPEN position.

(2) While valve is operating, move Ø SEL (phase selector switch to A Ø, B Ø and then to C Ø in turn. Read the AC voltmeter. Be sure to take the readings from each ammeter and AC voltmeter before the valve reaches the OPEN position.

(3) Operating voltages are: A phase ____________, B phase ____________, C phase ____________.

Note: The ammeters for each phase are calibrated in milliamps. (.1 amps = 100 milliamps)

(4) Operating current (amperage draw) for each phase is:

A phase ____________, B phase ____________, C phase ____________.

(5) Cycling time from close to open is _________ seconds.

(6) Now place switch S-5 to the CLOSE position.

(7) While valve is operating, move 0 SEL (phase selector) switch to A 0, B 0, and then to C 0 in turn. Read the AC voltmeter. Be sure to take the readings from each ammeter and AC voltmeter before the valve reaches the CLOSED position.

(8) Operating voltages are: A phase ___________, B phase ____________, C phase ____________.

(9) Operating current (amperage draw) for each phase is A phase ____________, B phase ____________, C phase ____________.

(10) Cycling time from open to close is ________ seconds.

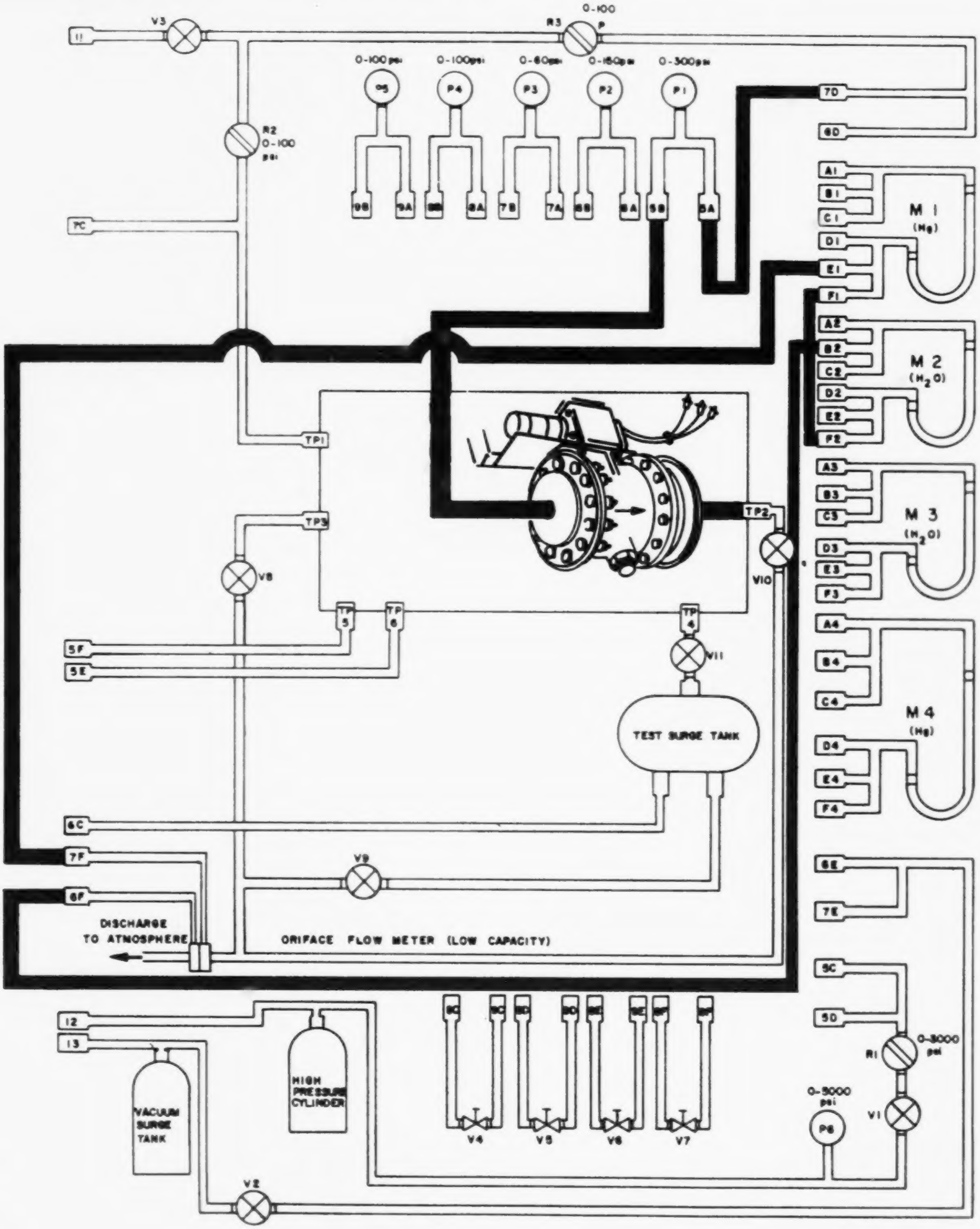
(11) Does the valve operate according to specifications? If your answer is yes, proceed to the next step.

If your answer is no, list the problems here. _________________

____

____.

(12) Place switch S-1 to the OFF position. Ask the instructor if you should proceed to the next step.


V3
11
R3
0-100
P
0-100 psi
0-100 psi
0-60 psi
0-160 psi
0-300 psi
P5
P4
P3
P2
P1
R2
0-100
psi
9B
9A
8B
8A
7B
7A
6B
6A
5B
5A
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7C
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F3
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(H2O)
A4
B4
C4
D4
E4
F4
M 4
(Hg)
TP1
TP3
TP2
V10
V8
TP 5
TP 6
TP 4
V11
5F
5E
TEST SURGE TANK
6C
7F
6F
V9
DISCHARGE
TO ATMOSPHERE
ORIFACE FLOW METER (LOW CAPACITY)
6E
7E
5C
5D
12
13
VACUUM
SURGE
TANK
HIGH
PRESSURE
CYLINDER
V4
V5
V6
V7
0-3000
psi
R1
0-3000
psi
P6
V1
V2

Figure 2. Test Facility Pneumatic Schematic.

7. Port Leakage Hookup

a. Figure 2 gives the proper way to hook the valve to the trainer. The heavy, black lines show how to hook each hose in order to make this check.

b. Make the necessary connections using hoses provided in the bottom of the trainer. Compare your hookup and figure 2 in the workbook with the test set up (figure 5) in the TO to see how much alike they are. Then hook one end of a hose to connection 7D on the trainer and connect the other end of the same hose to connection 5A. Continue until each hose is connected. DO NOT use a wrench to tighten the "B" nuts (hose connections) as finger tightness is sufficient for this test.

c. Check the valves and regulators on the trainer to be sure they are in the correct positions.

(1) Valves V8 and V9 are closed. (Full clockwise)

(2) Valve V10 is open. (Full counterclockwise)

(3) Turn regulators R2 and R3 counterclockwise until they turn freely. DO NOT turn the regulators too far or they will fall out and cause lose of air pressure.

Note: At this point let us take a few minutes to read about manometers. These instruments are used for measuring differential or absolute pressures. There are several types of liquids used in manometers. Oil, water (H_2O) or mercury (Hg) is used. The M-1 manometer is filled with mercury and the M-2 manometer is filled with water.

d. Manometer Settings

(1) Place the M-1 manometer on the inches mercury scale. The scale starts at 28 Hg. This is the manometer on the far left as you face the trainer. Turn the scale (set the scale by turning the knobs at the bottom of each manometer) so that the top of the mercury bubble (meniscus) is set to the barometric pressure of the day. Since we have no barometer here in the laboratory, set the scale at 30 Hg which is very close to the average daily barometric pressure.

(2) Place the M-2 manometer on the inches water scale so that the top of the bubble is on zero.

(3) Remove the steel cap from the 1 1/4 inch pipe. This pipe comes out from the left end of the trainer. Air can now flow through the orifice to the atmosphere.

8. Port Leakage Test

a. If you have followed the instructions carefully up to now, the position indicator on the valve should show full CLOSED position. Have instructor check valve position.

b. Turn V-3 fully counterclockwise. Air pressure is now at the trainer.

c. Valve V-10 should have been opened. This gives a path for the exhaust of air from the shutoff valve.

d. Turn R-3 clockwise until 70 psig shows on pressure gage P-1. DO NOT let the water in manometer M-2 rise above 55 inches. This is to keep you from accidentally pushing the water out of the top of the manometer.

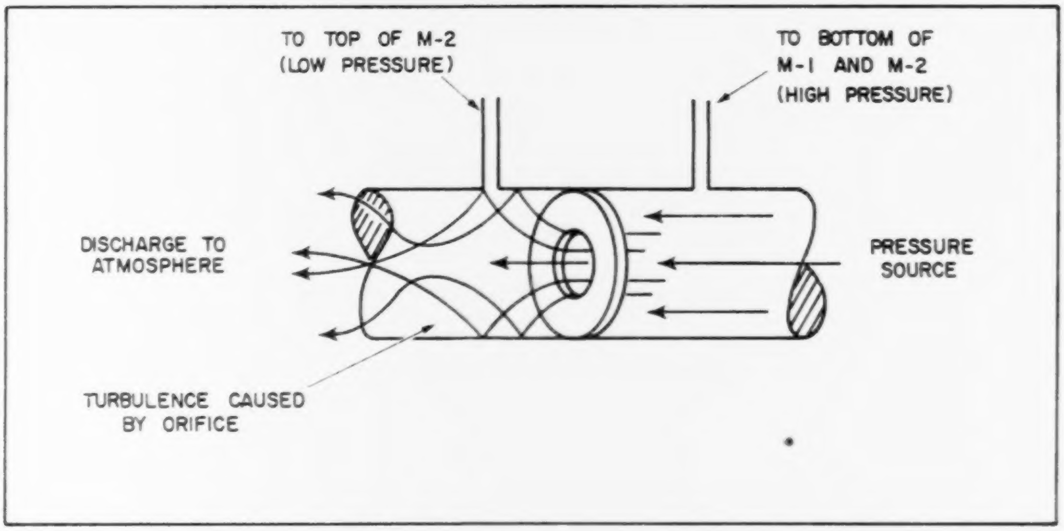


Figure 3. Typical Orifice in a Duct.

e. Trace the air flow through the trainer and valve (figure 2). Air in the trainer flows through V-3 and R-3 to connection 7D from 7D through pressure gage P1 and then to the valve. Even though the valve is closed, some air leaks through and goes through V-10 and on to the orifice. Air flow from the upstream side of the orifice goes through connections 7F to E1. From E1 air flows to the bottom of M-1 and at the same time air flows through fitting F1 to F2 and to the bottom of M-2. The mercury manometer (M-1) now reads the absolute pressure that goes through the valve end to the orifice. This high pressure will push the water up in manometer M-2. After the air goes through the orifice, the pressure will drop due to turbulence caused by the restrictions (see figure 3). This low pressure air flows through fitting 6F to B2 and in the top of manometer M-2 and tries to push the water down. The two air flows meet and stabilize in M-2. This is where the differential pressure reading is made.

You will use this reading (value) later on to find if the valve is leaking too much.

f. What is the reading on the M-1 manometer?

______________________. Keep in mind your answer must be in inches Hg.

g. What is the reading on the M-2 manometer?

______________________. This time your answer must be in inches H_2O.

h. The next step is to find if the leakage in the valve is within normal limits. There is some math used here, so before we start figuring, first drop pressure on the trainer to be safe.

i. Turn regulator R-3 counterclockwise until it turns freely and pressure gage P-1 drops to zero.

j. Close shutoff valve V-3 (full clockwise).

k. The amount of air that goes through the closed butterfly is measured in pounds per minute (PPM). The formula used to determine the amount of leakage is as follows:

$$\Sigma\Delta P = \frac{17.35 \times P_1}{T_1 + 460} \times \Delta P$$

(1) Do not panic now! Let us see just what all of this means. First, $\Sigma\Delta P$ is called SIGMA, DELTA, P. The number on the right side of the equal sign is called the conversion factor. The first thing that must be done is to make this conversion factor into a single number. We do this by converting all of the unknown figures such as P_1, T_1, and ΔP into known ones. P_1 is the M-1 manometer reading. ΔP is the M-2 manometer reading (the difference in pressure between one side of the orifice and the other). T_1 is the temperature of the air.

Note: The thermometer is located by the laboratory window.

(2) Rewrite the formula with the known figures in place of the unknowns. Solve a problem just for practice.

(3) Assume we have just made some readings. M-1 manometer reads 33, M-2 manometer reads 26 and the temperature is 68°F.

STEP 1: WRITE THE FORMULA.

$$\Sigma\Delta P = \frac{17.35 \text{ X } P_1}{T_1 + 460} \text{ X } \Delta P$$

STEP 2: REWRITE THE FORMULA USING KNOWN NUMBERS IN PLACE OF UNKNOWN ONES. $P_1 = 33$, $\Delta P = 26$, $T_1 = 68$

$$\Sigma\Delta P = \frac{17.35 \text{ X } 33}{68 + 460} \text{ X } 26$$

STEP 3: MULTIPLY 17.35 by P_1 (33). DON'T FORGET THAT DECIMAL POINT.

$$\begin{array}{r} 17.35 \\ \underline{\text{X } 33} \\ 5205 \\ \underline{5205} \\ 572.55 \end{array}$$

STEP 4: NOW, ADD 460 TO T_1 (68).

$$\begin{array}{r} 460 \\ \underline{+68} \\ 528 \end{array}$$

STEP 5: AT THIS POINT, REWRITE THE FORMULA TO SEE WHAT YOU HAVE THUS FAR.

$$\Sigma\Delta P = \frac{572.55}{528} \text{ X } 26$$

STEP 6: DIVIDE THE BOTTOM HALF OF THE FRACTION INTO THE TOP HALF. CARRY OUT TO ONLY TWO DECIMAL PLACES.

$$\begin{array}{r} 1.08 \\ 528\overline{)572.55} \\ \underline{528} \\ 4455 \\ \underline{4224} \\ 231 \end{array}$$

AGAIN, REWRITE THE FORMULA. $\Sigma\Delta P = 1.08 \text{ X } 26$

STEP 7: MULTIPLY. ONCE AGAIN, DON'T FORGET THE DECIMAL POINT.

$$\begin{array}{r} 1.08 \\ \underline{\text{X } 26} \\ 648 \\ \underline{216} \\ 28.08 \end{array}$$

STEP 8: THE ANSWER IS ROUNDED OFF TO THE NEAREST WHOLE NUMBER MAKING IT AN EVEN 28. THEREFORE, $\Sigma\Delta P = 28$ WHICH IS THE FINAL CONVERSION FACTOR.

STEP 9: Figure 4 is a flow chart that will show the allowable leakage of a valve when the leakage test is made using a .150 orifice. Each shop will have a complete set of orifices and charts to use for each valve tested. Since the 3038 trainer has a .150 orifice, let us see how the flow chart works.

(1) Find the conversion factor (28) on the left side of the chart. Follow the horizontal line to the right until it intersects with the diagonal line.

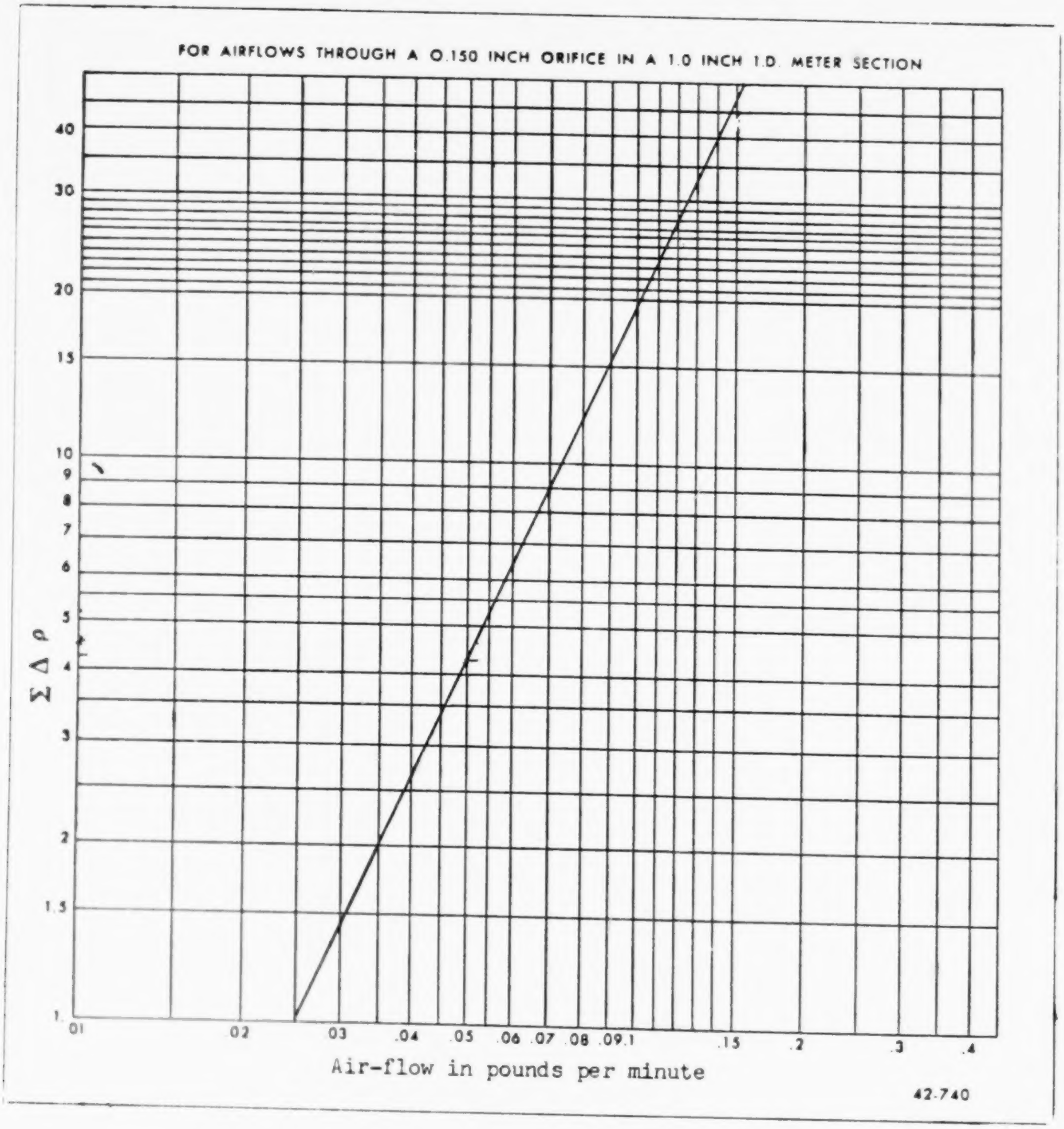


Figure 4. Air Flow Chart.

(2) At the point where the two lines intersect, follow the vertical line to the bottom of the chart. As you can see, the line ends at the bottom of the chart on the number .12. This means that the valve under test is leaking at the rate of .12 PPM.

> Note: Different valves have different allowable port leakages, but the procedure for port leakage testing is the same for all valves.

l. Now rewrite the formula and use the manometer readings from your valve to find $\Sigma\Delta P$. Once you find $\Sigma\Delta P$, use the flow chart to find out how much your valve is leaking.

(1) Read paragraph 8c in the TO.

(2) How much port leakage is allowed? ______________

(3) Is the valve leaking too much? ________________

(4) If the leakage is more than the specified amount,

__________________________________ or fix other causes of leakage before going to the other tests.

Note: At this time have the instructor check your work.

m. Conclusion of leakage test

(1) Disconnect and plug the end of each hose. Store them in the bottom of the trainer cabinet.

(2) Remove all electrical wires and lay them to one side for the next project.

(3) Cap all ports and cover the electrical connectors on the valve. Stow the valve in equipment locker number 2.

(4) If any of the equipment (hoses, wires, nuts, caps, plugs) was damaged or missing, notify the instructor and he/she will see that the corrections are made.

INSTRUCTOR ASSISTS:

1. _________ 2. _________

Section 3. SHUTOFF VALVE: BENCH CHECK OF THE MOTOR ACTUATED BUTTERFLY SHUTOFF VALVE ASSEMBLY

EQUIPMENT

Electrical pneumatic trainer number 3038
Valve part number 121535-1
TO 15A2-2-52-83

PROCEDURE

1. Use trainer number 3038 to bench check a motor actuated butterfly shutoff valve. This check is to find if the valve meets the technical order operating specifications and to check the butterfly valve for correct electrical operation.

2. Go to equipment locker number 2 and get the shutoff valve assembly with the part number 121535-1.

3. Sign out TO 15A2-2-52-83 from the TO file.

a. In the TO find the operating specifications for valve part number 121535-1 and complete the following statements:

(1) Operating pressure differential across the butterfly at +570°F is ______________________________.

(2) Operating voltage is ____________________.

(3) Stall current at 26V DC and +21°C is ________________________.

(4) Operating time from open to close is ___________.

(5) Operating time from close to open is ___________.

b. Visually inspect the valve for the following:

(1) Corrosion on the butterfly and housing.

(2) Cracked valve housing.

(3) Damaged threads on the electrical connector plug.

QUESTION

What should be done if any component of the shaft assembly or disc assembly shows wear or damage beyond minor repair? ___________

____

4. Trainer Preparation.

a. Make sure that each switch is in the OFF position.

b. The trainer should still be hooked to the proper wall receptacle from the previous test.

5. Electrical Hookup.

a. Follow the hookup shown on foldout 2.

b. The connections will be made with the wires at the trainer.

c. Hook the connector plug of the valve to the correct electrical pins on the trainer electrical patching panel.

> Caution: At this point check the connections before you go to the next step. This prevents the danger of a short circuit due to crossed wires. Have the instructor check your hookup.

6. Operation of the valve.

a. Place switch S-1 to the ON position. This turns on the power to the trainer. Place switch Ø SEL to 1Ø. The AC voltmeter should show 110 to 120 volts. The DC voltmeter should show 24 to 28 volts. If you do not have these readings, recheck your hookup and/or the voltage adjustment potentiometer (see (A) in figure 1). The potentiometer should be set to full increase.

b. Check the valve position indicator to see if the valve is opened or closed.

(1) If the valve is open, place switch S-2 to the #2 position and the valve should close.

(2) If the valve is closed, place switch S-2 to the #3 position and the valve should open.

c. Complete the following statements. First put the valve in position to make the check. Take the readings from the correct meters or gages on the trainer.

Note: Reset the timer before operating the valve.

(1) Cycling time from open to close is __________ seconds.

(2) Operating voltage is __________ volts DC. Be sure to read the DC voltmeter.

(3) Operating current (amperage draw) is __________ amps. Be sure to read the DC ammeter.

Note: Reset the timer.

(4) Place switch S-2 to the appropriate position and complete the following statements.

(5) Cycling time from close to open is __________ seconds.

(6) Operating voltage is __________ volts DC. Be sure to read the DC voltmeter.

(7) Operating current (amperage draw) is __________ amps. Be sure to read the DC ammeter.

(8) Does the valve operate according to the TO specifications? ____

(9) Place switch S-1 to the OFF position.

7. Disconnect the valve from the trainer.

a. Remove the electrical wires connecting the valve to the trainer and lay them aside for the next project.

b. Cap all ports and cover electrical connectors on the valve. Stow the valve in equipment locker number 2.

c. If any of the equipment (wires, caps, plugs) was damaged or missing, notify the instructor and he will see that corrections are made.

8. If no discrepancies were noted, go to the next project.

INSTRUCTOR ASSISTS:

1. __________ 2. __________

Section 4. SHUTOFF VALVE: BENCH CHECK OF THE POWER OPERATED BUTTERFLY VALVE

EQUIPMENT

Electrical pneumatic trainer number 3038
Valve part number 657T100-5
TO 15A2-2-92-3

PROCEDURE

1. Use trainer number 3038 to bench check a power operated butterfly valve. This check is to find if the valve meets the technical order operating specifications and to check the butterfly valve for correct electrical operation.

2. Go to equipment locker number 2 and get the valve assembly with the part number 657T100-5.

3. Sign out TO 15A2-2-92-3 from the TO file.

a. In the TO find the operating specifications for the valve and complete the following statements:

(1) Rated operating pressure is ____________________.

(2) Operating voltage is ______________________.

(3) Running current is ____________________________.

(4) Stroke time should be __________________________.

b. Visually inspect the valve for the following:

(1) Corrosion on the butterfly and housing. What should you do if corrosion is found? ____________________________

____.

(2) Heat discoloration on painted surfaces. What would be done to repair the painted surfaces? ______________________

____.

(3) Damaged threads on the connector plug. How are they repaired? ____

____.

4. Trainer preparation

a. Make sure that each switch is in the OFF position.

b. The trainer should still be hooked to the proper wall receptacles from the previous test.

5. Electrical hookup

a. Follow the hookup shown on foldout 3.

b. The connections will be made by using the wires at the trainer.

c. Hook the connector plug of the valve to the correct electrical pins on the trainer electrical patching panel.

Caution: At this point check your connections before going to the next step. This prevents the danger of a short circuit due to crossed wires. Have the instructor check your hookup.

6. Operation of the valve

a. Place switch S-1 to the ON position. The AC voltmeter should show 110 to 120 volts. The DC voltmeter should show 24 to 28 volts. If you do not have these readings, read paragraph 6a, section 2 for corrective action.

b. Check the valve position indicator to find if the valve is opened or closed.

Note: Reset the timer before operating the valve.

(1) If the valve is open, place switch S-4 to the close position. The valve should close. If the valve was closed, leave it there.

c. Complete the following statements. First put the valve in position to make the check. Take the readings from the correct meters or gages on the trainer. Place switch S-4 to the open position.

(1) Cycling time from close to open is __________ seconds.

(2) Operating voltage is __________ volts. Be sure to read the AC voltmeter.

(3) Running current is __________ amps.

d. Set the Ø SEL switch to 1Ø and read the ammeter labeled SGL Ø.

Note: Reset the timer before the next operation.

e. Place switch S-4 to the CLOSED position.

(1) Cycling time from open to close is __________ seconds.

(2) Operating voltage is __________ volts. Be sure to read the AC voltmeter.

f. Set the Ø SEL switch to 1Ø and read the ammeter labeled SGL Ø.

g. Place switch S-4 to the CLOSED position.

h. Does the valve operate according to the TO specifications? ____

If it does, very good. If the valve will not move, what is the probable cause? ____.

____.

What remedy should be taken? ____________________________

____.

i. Place switch S-1 to the OFF position.

7. Disconnect the valve from the trainer.

a. Remove the electrical wires connecting the valve to the trainer and lay them aside for the next project.

b. Cap all ports and cover electrical connectors on the valve. Stow the valve in equipment locker number 2.

c. If any of the equipment (wires, caps, plugs) was damaged or missing, notify the instructor and he/she will see that corrections are made.

8. If no discrepancies were noted, proceed to the next project.

INSTRUCTOR ASSISTS:

1. __________ 2. __________

Section 5. SHUTOFF VALVE: BENCH CHECK OF A TWO-AND-ONE-HALF INCH DIAMETER PNEUMATIC SHUTOFF VALVE

EQUIPMENT

Electrical pneumatic trainer number 3038
Valve part number 122142
TO 1B-52B-06
TO 9P5-5-59-43

PROCEDURE

1. Use trainer number 3038 to bench check a two-and-one-half inch diameter pneumatic shutoff valve. This check is to find if the valve meets the technical order operating specifications and to check the solenoid and butterfly for correct operation.

2. Go to equipment locker number 2 and get the valve assembly with the part number 122142.

3. Sign out TO 9P5-5-59-43 from the TO file.

a. In the TO find the operating specifications for the valve and complete the statements.

(1) Valve normal position is ________________________.

(2) The operating voltage requirement is ____________.

(3) The operating current is ________________________.

(4) Actuating time closed to open or open to closed should not exceed ___________________ maximum.

b. If you had to disassemble the valve for repair, all parts would have to be cleaned and inspected. Let us see what the TO says about the cleaning process.

(1) All parts, except those to be replaced, are cleaned with ____ and dried thoroughly.

(2) Air passages are cleaned thoroughly with ________ ____.

(3) Before installing new bearings, they should be cleaned with ____.

c. Inspection: Using the TO, refer to paragraph 4 and figure 8 to make the following checks.

> Note: You will need an ohmmeter for one of these checks so go to equipment locker number 1 and get a multimeter with the number ME-77 C/U.

(1) Use the ohmmeter to measure the resistance of the solenoid. This check is made across pins A and B of the valve.

What reading did you get? ____________________

(2) The TO states that the resistance must be between __________ and __________ ohms. If the resistance of the solenoid is not within this range the solenoid would have to be replace. Once the resistance check is made, disconnect the multimeter and return it to equipment locker number 1.

(3) Check maximum operating voltage as follows: Use the electrical wires at the trainer. Hook solenoid pin (A) to trainer pin (F). Solenoid pin (B) is hooked to trainer pin (R). Turn switch S-1 to the ON position. Turn the voltage adjustment potentiometer to full decrease. Turn switch S-2 to position 3. This will energize the solenoid. SLOWLY turn the voltage adjustment potentiometer toward full increase until you hear a click in the solenoid.

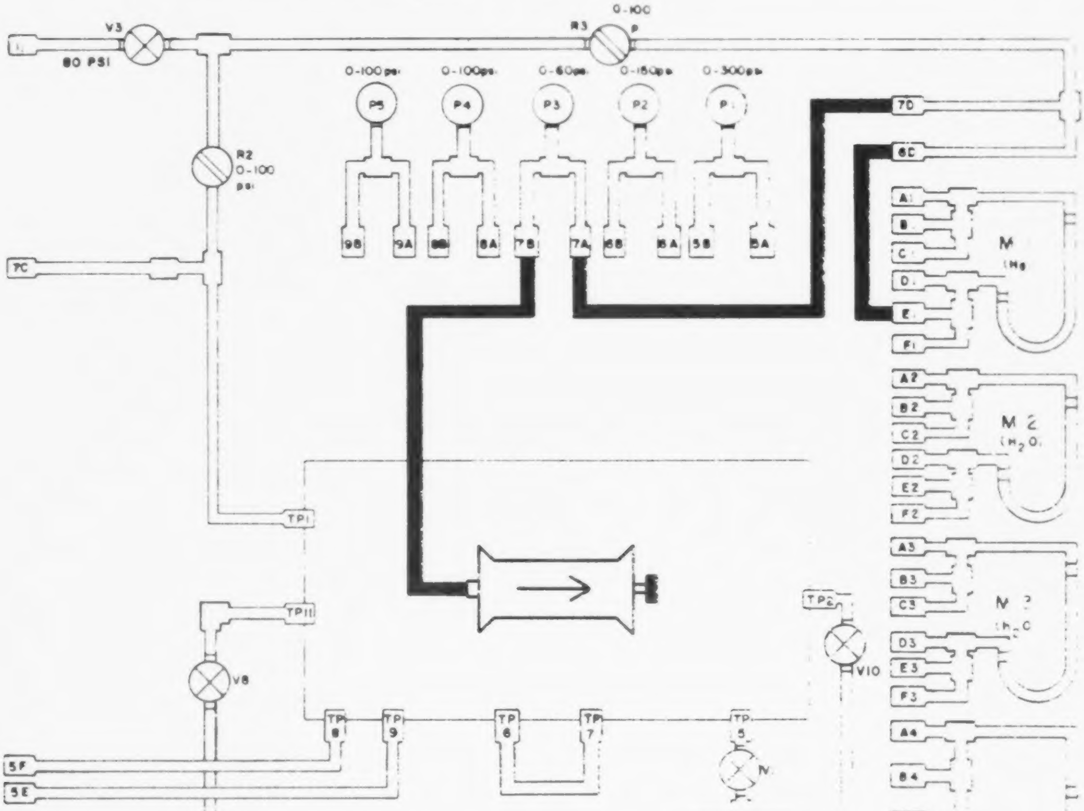

V3
80 PSI
R3
0-100
R2
0-100
psi
0-100psi
0-100psi
0-60psi
0-150psi
0-300psi
P5
P4
P3
P2
P1
9B
9A
8B
8A
7B
7A
6B
6A
5B
5A
7D
6C
7C
A1
B1
C1
D1
E1
F1
M
(Hg
A2
B2
C2
D2
E2
F2
M 2
(H2O)
A3
B3
C3
D3
E3
F3
M 3
(H2O
A4
B4
C4
D4
E4
F4
M 4
(Hg
TP1
TP11
TP2
V8
V10
TP 8
TP 9
TP 6
TP 7
TP 5
5F
5E
6C
TEST SURGE TANK

Figure 5. Pneumatic Valve Test Setup.

BEST COPY AVAILABLE

(4) Read the DC voltmeter at the sound of the click. What is the voltage? ______________. The technical order lists the maximum voltage required to energize the solenoid as ______________.

(5) Turn switches S-1 and S-2 to the OFF position and the voltage adjustment potentiometer to full increase in that order.

d. Operational Check.

(1) Using figure 5, hook each pneumatic hose (heavy dark lines) to the valve and the trainer. M-1 manometer scale should be set to read zero on the inches of mercury scale.

(2) Place switch S-1 to ON.

(3) Open valve V-3.

(4) Slowly build pressure by turning regulator R-3 clockwise until the valve indicator shows closed. This should happen as soon as pressure is applied. If not, your hookup must be wrong.

(5) Once the valve is closed, reduce the pressure by turning regulator R-3 counterclockwise until manometer M-1 shows zero.

(6) Place switch S-2 to position 3.

Caution: You MUST keep an eye on manometer M-1 during the next step or you may blow the mercury out of the top of the manometer. BE CAREFUL!

(7) With regulator R-3, SLOWLY build pressure and closely watch the valve indicator. When the indicator shows that the valve is open, stop applying pressure.

(8) The valve should have opened between 9.0 and 14.0 inches of Hg.

(9) What was the manometer reading? ______________

(10) How is minimum opening pressure adjusted? ______

____.

(11) Reduce the pressure to zero by turning regulator R-3 counterclockwise.

(12) How much time is allowed for the butterfly to open and close? ____.

(13) Disconnect the line to manometer M-1 and cap the connections. This is the line that goes from 6D to E1 on the trainer.

Have instructor check your work __________.

(14) Turn regulator R-3 clockwise until gage P-3 shows 80 psig.

(15) Energize and deenergize the solenoid by switching switch S-2 between position 3 and OFF. Do this several times while closely observing the valve indicator. Does the valve open and close within the TO time specifications? __________

Note: You have to guess the operating time of the butterfly since the trainer timer cannot be started and stopped in only one second.

(16) Check the TO troubleshooting table for corrective action if the valve operates too slowly.

(17) Place switch S-1 to OFF, close valve V-3 and turn regulator R-3 counterclockwise until it turns freely.

(18) Disconnect all the equipment and stow in the proper places.

(19) Disconnect the trainer power cables and clean your area. You must check with the instructor for instructions.

INSTRUCTOR ASSISTS:

1. __________ 2. __________

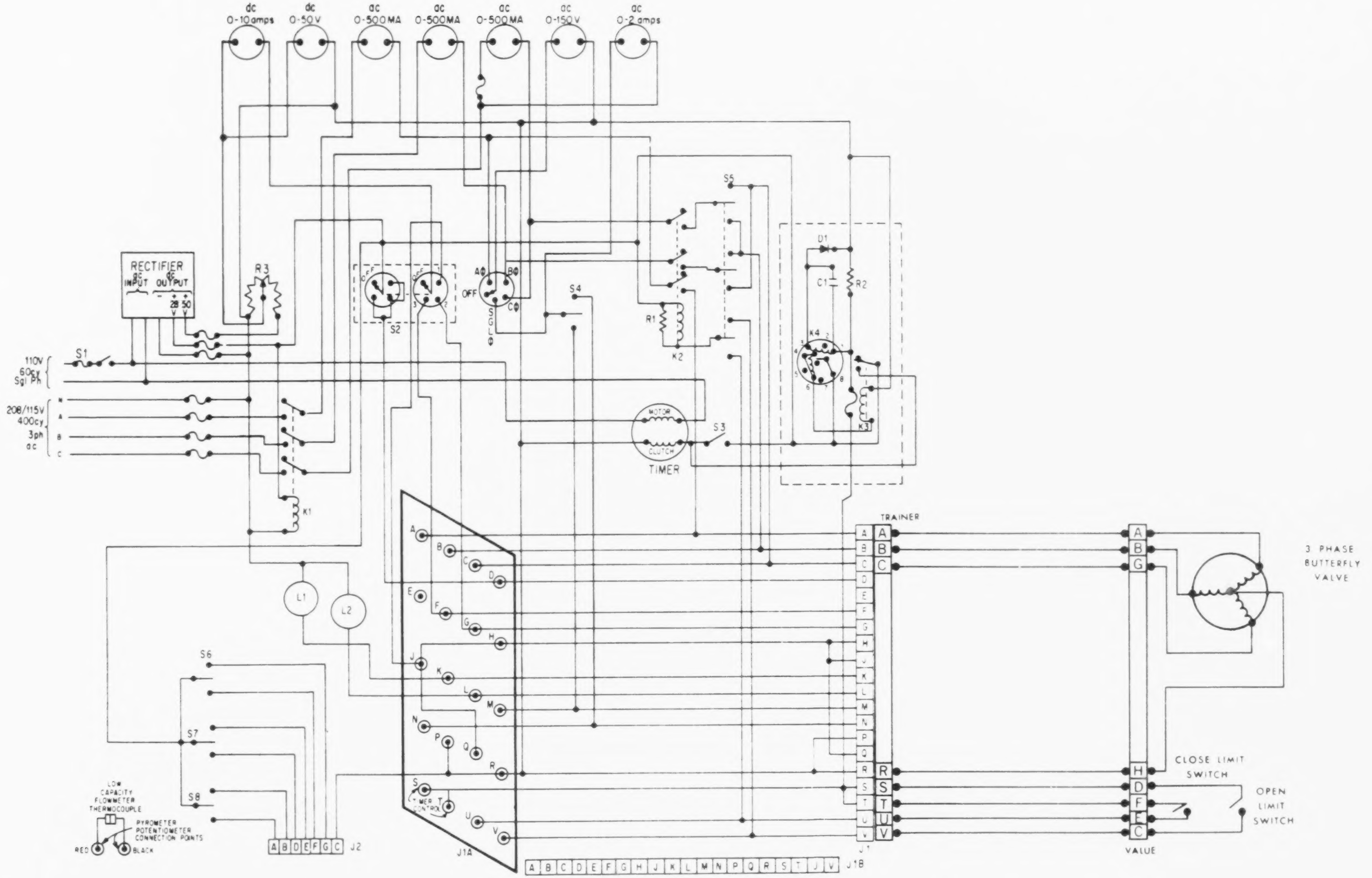
e. Maintenance Documentation.

(1) Get an AFTO Form 349 and AFTO Form 350 from the instructor.

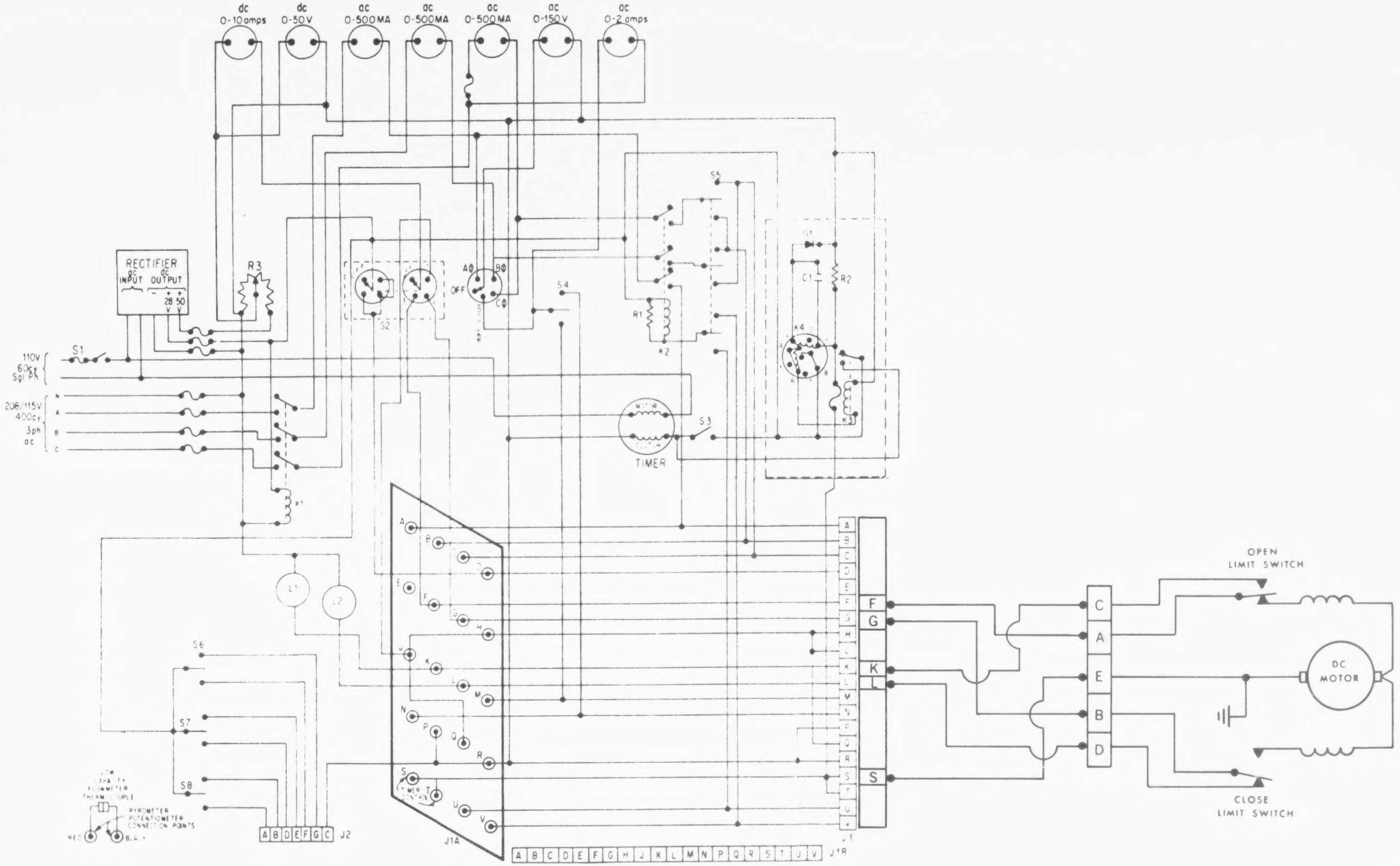
(2) Use the information on the AFTO Form 350 and the note to help you make the entries on the AFTO Form 349.

Note: The mechanic who removed this unit from the aircraft had to use an AFTO Form 349 to account for the time used in removing the unit. At the same time an AFTO Form 350 is made, attached to the unit, and the unit routed to RPC. RPC sent the unit to your shop (work center C3360) for the work that would be needed to make the unit serviceable. You made a bench check of the unit to try to find why it did not work (block 14, AFTO Form 350) but, the unit checked out OK. Even though the valve checked OK and no repair was made, you must use an AFTO Form 349 to show the time you used to check the unit. This is what you are to do now. Keep in mind, the malfunction code used should show the corrective action you took.

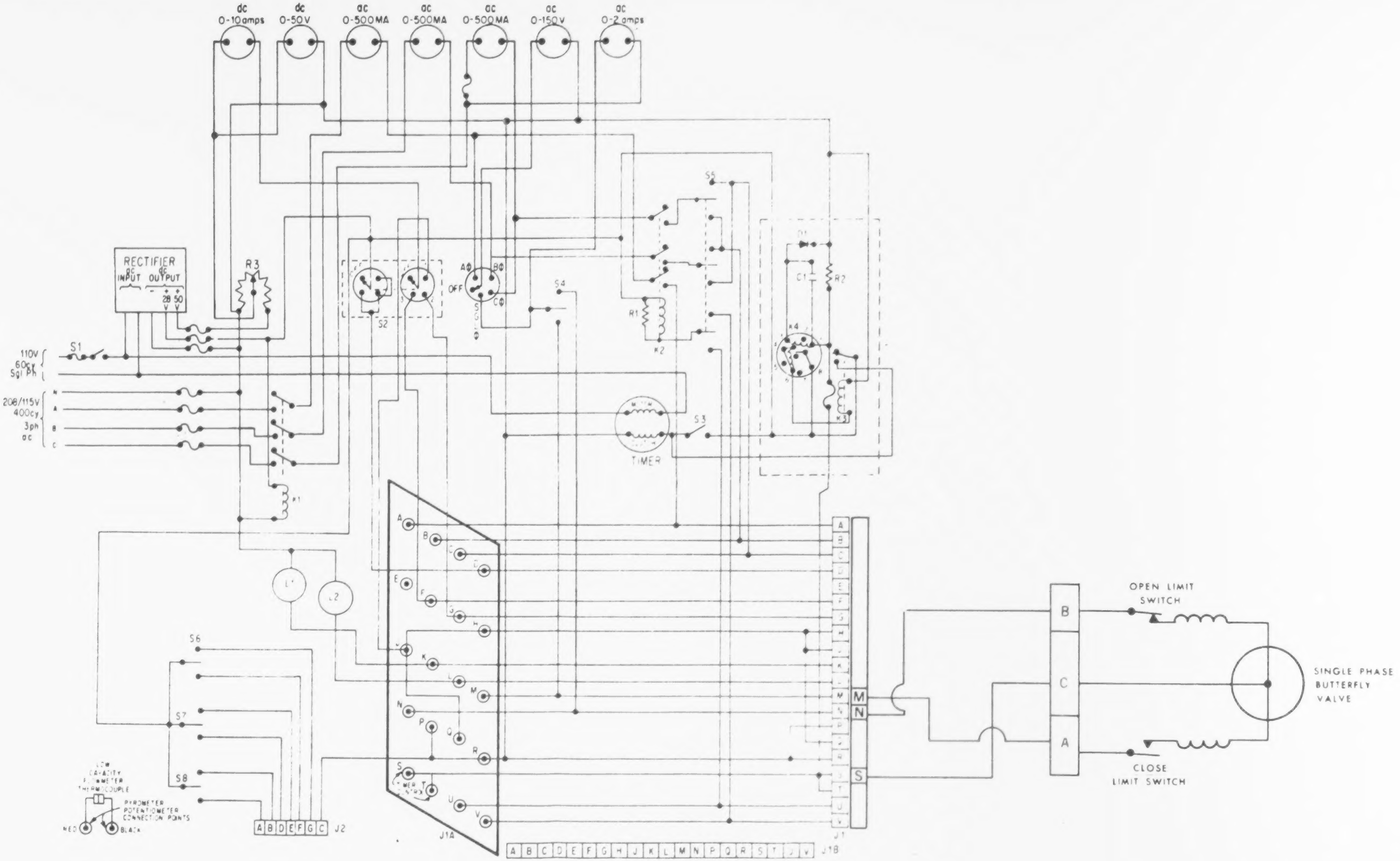
(3) Have the instructor check your AFTO Form 349 before you go on to the next project.


dc 0-10 amps
dc 0-50V
ac 0-500MA
ac 0-500MA
ac 0-500MA
ac 0-150V
ac 0-2 amps
RECTIFIER
ac INPUT
dc OUTPUT
28 V
50 V
R3
S2
OFF
AΦ
BΦ
CΦ
SGL Φ
S4
S5
R1
K2
D1
C1
R2
K4
K3
S1
110V 60cy Sgl Ph
208/115V 400cy 3ph ac
N
A
B
C
K1
MOTOR
CLUTCH
TIMER
S3
L1
L2
S6
S7
S8
LOW CAPACITY FLOWMETER THERMOCOUPLE
PYROMETER POTENTIOMETER CONNECTION POINTS
RED
BLACK
J2
TIMER CONTROL
J1A
J1B
J1
TRAINER
VALVE
3 PHASE BUTTERFLY VALVE
CLOSE LIMIT SWITCH
OPEN LIMIT SWITCH

Foldout 1. Test Facility Electrical Schematic.


dc 0-10 amps
dc 0-50V
ac 0-500MA
ac 0-500MA
ac 0-500MA
ac 0-150V
ac 0-2 amps
RECTIFIER
ac INPUT
dc OUTPUT
28 V
50 V
R3
S1
110V 60cy Sgl Ph
208/115V 400cy 3ph ac
N
A
B
C
K1
S2
AΦ
BΦ
CΦ
OFF
S4
S5
R1
K2
D1
C1
R2
K4
K3
S3
MOTOR
CLUTCH
TIMER
L1
L2
S6
S7
S8
LOW CAPACITY FLOWMETER THERMOCOUPLE
PYROMETER POTENTIOMETER CONNECTION POINTS
RED
BLACK
A B D E F G C
J2
J1A
TIMER CONTROL
A B C D E F G H J K L M N P Q R S T U V
J1B
J1
F
G
K
L
S
C
A
E
B
D
OPEN LIMIT SWITCH
CLOSE LIMIT SWITCH
DC MOTOR

Foldout 2. Test Facility Electrical Schematic.


dc 0-10amps
dc 0-50V
ac 0-500MA
ac 0-500MA
ac 0-500MA
ac 0-150v
ac 0-2 amps
RECTIFIER
ac INPUT
dc OUTPUT
- + +
28 V
50 V
R3
S1
110V 60cy Sgl Ph
208/115V 400cy 3ph ac
N
A
B
C
S2
AΦ
BΦ
OFF
CΦ
SGL Φ
S4
S5
R1
K2
D1
C1
R2
K4
K3
S3
TIMER
K1
L1
L2
S6
S7
S8
LOW CAPACITY FLOWMETER THERMOCOUPLE
PYROMETER POTENTIOMETER CONNECTION POINTS
RED
BLACK
A B D E F G C
J2
J1A
A B C D E F G H J K L M N P Q R S T U V
J1B
J1
M
N
S
B
C
A
OPEN LIMIT SWITCH
CLOSE LIMIT SWITCH
SINGLE PHASE BUTTERFLY VALVE

Foldout 3. Test Facility Electrical Schematic.

WORKBOOK

C3ABR42331-WB-312

Technical Training

Aircraft Environmental Systems Mechanic

CONTROLS OF MB-3 LEAKAGE TESTER

12 JUNE 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

Environmental Pneudraulic Branch
Chanute AFB, Illinois

C3ABR42331-WB-316

OPERATION OF MB-3 LEAKAGE TESTER

OBJECTIVE

Using applicable TO containing a diagram of the control panel of a cabin pressure leakage tester, relate the controls and gages to their function with 80% accuracy.

EQUIPMENT

TO 33A4-4-10-1

PROCEDURE

This package presents information to you in the form of questions and incomplete statements. Read the TO closely, answer the questions and complete the statements by writing the necessary information in the blank space provided. CAUTION: Don´t just skim through the TO looking for key words or phrases that help you find the answers. Study the information in the TO and make sure you understand it. In the very next lesson you will be required to pressurize an aircraft cabin using this tester. So, learn the material well and save yourself some time later on.

Take TO 33A4-4-10-1 from the file and open it to section I.

1. What is the name of the company that makes the MB-3 cabin leakage tester? ____

____

2. The tester is designed to supply ____________ to aircraft cabins at ______________________________ for ____________ ________________ under ______________________________.

Supersedes 3ABR42331-WB-316, 7 August 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 250; DAV - 1

3. How much air and pressure is the tester capable of producing?

____

____

4. Is the tester suitable for use under world-wide climatic conditions? ______________________________

5. The instrument panel contains instrumentation to indicate

____________________, ____________________,

____________________, ____________________

____________________ and ____________________.

6. The tester is shipped wired for __________ volt service.

Note: Refer to paragraph 1-12 and 1-14 to complete questions 7 thru 21.

7. The blower pressure gage indicates ____________________

______________ of the blower.

8. The cabin pressure gage indicates ____________________

______________ of the aircraft under test.

9. The rate of cabin pressure change indicator is a standard

________________________ with a special dial to

indicate __________ or __________ pressures rather

than __________ or __________.

10. What is the purpose of the air temperature indicator?

____

____

11. What does the canopy seal pressure indicator show?

____

BEST COPY AVAILABLE

12. What is another name for the cabin pressure regulator?

____

13. What does it control? ______________________

____

14. The canopy seal air regulator ______________

______________ in the ______________________.

15. How is the dump valve operated? ______________

16. What does the dump valve control? ____________

____

17. What does the flowmeter do? __________________

____

18. Refer to figure 1 in this text and figure 4-1 in the TO and label the components represented by a letter.

a. ______________

b. ______________

c. ______________

d. ______________

e. ______________

f. ______________

g. ______________

h. ______________

i. ______________

j. ______________

k. ______________

Study TO paragraph 4-10 closey and answer the following questions.

33. What is the approximate weight of one cubic foot of air at 70 degrees F and 14.7 psia? ______________________________

34. Take the answer that you got for question 32 and convert it to pounds per minute by the method outlined in TO paragraph 4-10. What is your answer? ______________________________

If your answer is not 9.165 ppm you have made a mistake. Go back to question 32 and try again.

35. If the air temperature should exceed 150 degrees F or if barometric pressure was something other than 14.7 psia, you would have to use the chart shown in TO figure 4-4 to convert CFM to PPM. We won´t have you learn this chart since most all aircraft TOs limit air temperature for leakage tests to 120 degrees F.

Note: Refer to paragraph 4-4 to answer the following questions by filling in the blanks.

36. The cabin pressure regulator determines

____

____

37. The dump valve is used to ______________________________

____

____

____

Clockwise rotation ____________ the valve.

38. The canopy seal air regulator controls

____

Turning this control clockwise

____

Note: After you have completed this workbook, return it to the instructor for grading.

PROGRAMMED TEXT

C3ABR42331-PT-312A

Technical Training

Aircraft Environmental System Mechanic

PRINCIPLES OF AIRFLOW CONTROL AND SHUTOFF VALVE

4 June 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: 8.9

OBJECTIVES

1. Specify the principle of air flow control with 80% accuracy.

2. Relate the components of an airflow control and shutoff valve to their operation with 80% accuracy.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." Read the material presented in each frame and respond as directed. After each frame you are required to answer true/false statements, multiple choice questions, match statements, or identify a part on a drawing. DO NOT MARK IN THIS TEXT. After making your response, check the accuracy at the top of the following page. If your answer is not correct, go over the material until you understand the reason for your error before going to the next frame.

INTRODUCTION

This text was prepared to help you to learn to maintain the Airflow Control and Shutoff Valve. You will learn to identify and explain the function of each of its parts, and how to make the necessary checks and adjustments. A numbered schematic is included in figure 1 to help you see the relationship of the components.

The first thing we will discuss is the operation of the parts which make up the airflow control and shutoff device. They are:

1. venturi
2. servo controller
3. pressure regulator
4. solenoid valve "A"
5. pneumatic actuator
6. altitude compensator
7. solenoid valve "B"
8. manual override control
9. filter

After becoming familiar with these parts, you will see how they operate, step-by-step. Locate each part on figure 1 as we discuss it.

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DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; DAV - 1

The venturi, figure 2 (1), forms the base for the airflow control and shutoff valve. With no butterfly valve, the venturi is just a flow limiting device; it is not a control device. Take a close look at the venturi. Notice that the center of the venturi is smaller than either of its ends. This center part is the throat. The inlet is located to the right of the throat and is the base of the venturi. The throat and the base of the venturi both have tap-off connections through which the air pressure is taken to operate the valve. The tap-off at the throat is labeled (A) and the one at the base is labeled (B). The pressures from the throat and the base provide the valve with differential pressures. Basically, differential pressures are different pressures. When a flow of air is sent through the venturi from the base to the throat as shown in figure 2, it gives an effect that is known as Bernoulli's Principle.

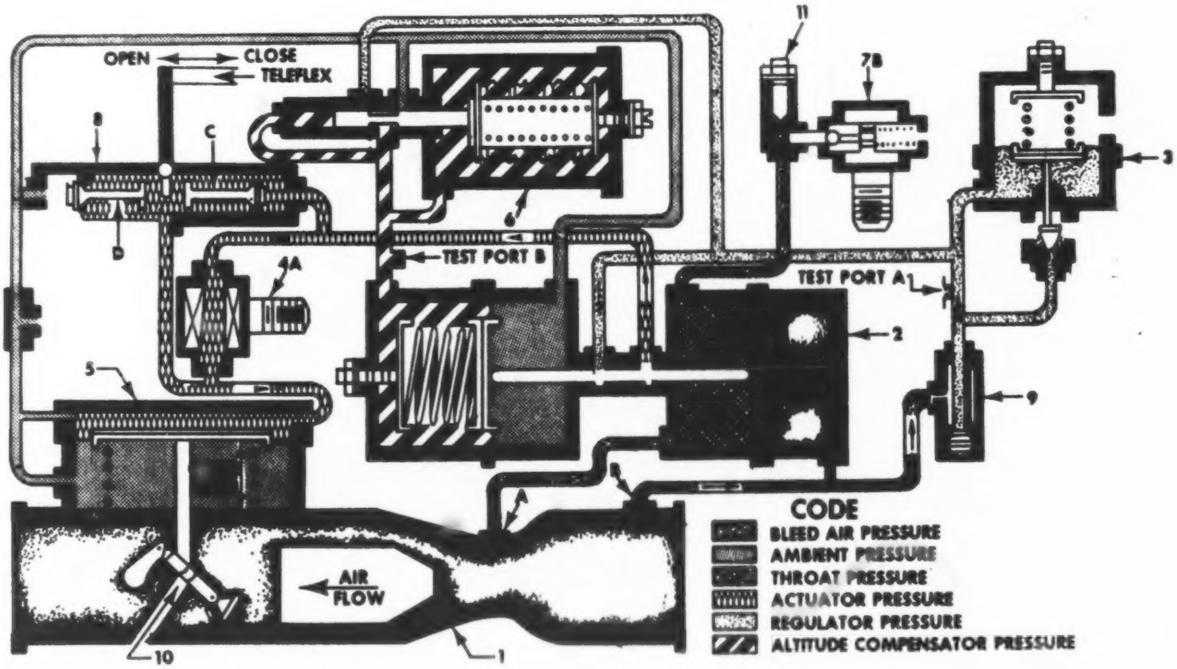
OPEN
CLOSE
TELEFLEX
8
C
D
6
11
7B
3
4A
TEST PORT B
TEST PORT A
2
5
9
A
B
AIR FLOW
10
1
CODE
BLEED AIR PRESSURE
AMBIENT PRESSURE
THROAT PRESSURE
ACTUATOR PRESSURE
REGULATOR PRESSURE
ALTITUDE COMPENSATOR PRESSURE

Figure 1. Airflow Control and Shutoff Valve.

FRAME 2

Bernoulli's Principle has its roots in fluid mechanics. Basically, it states that the pressure exerted by a moving fluid decreases when the fluid speeds up and increases when the fluid slows down. For example, suppose that water is being forced through a horizontal pipe, one section of which is narrower than the rest. The water has to flow faster through the narrow section and thus must exert less pressure there than on the other sections. This principle also applies to airflow. As you can see in figure 2, the pressure at point B is less than that at points A or C.

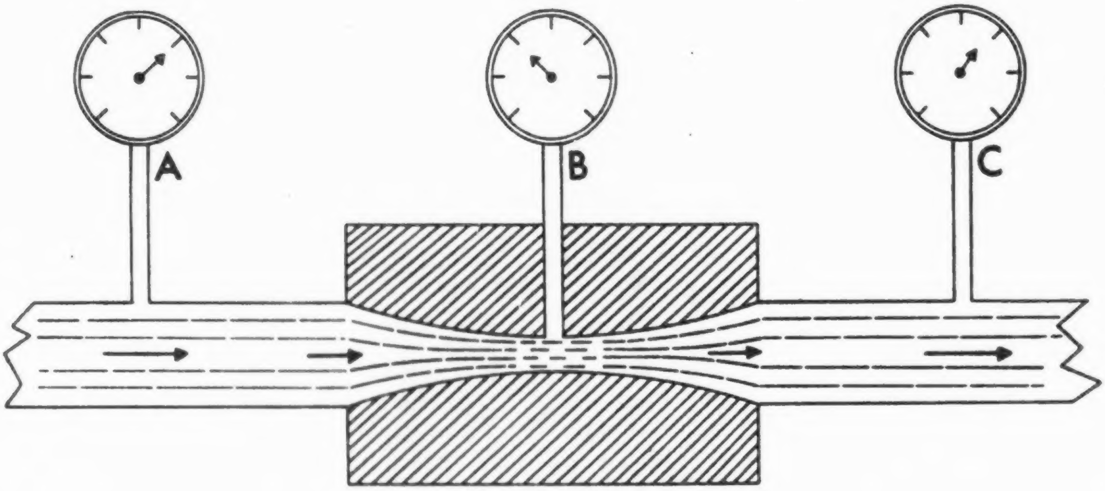

Figure 2. Bernoulli's Principle.

Pick the statements that are true (T) and those that are false (F).

1. The venturi is a flow limiting device.

2. The venturi is a source of differential pressure.

3. As the speed of air through the throat of the venturi increases, pressure at the throat will drop.

Answers to Frame 2. 1. T 2. T 3. T

FRAME 3

The servo controller, shown in figure 1 (2) and figure 3, is made up of two diaphragm control sections, the main or primary servo section and the secondary servo section. Each servo section is made up of an air chamber divided by a diaphragm. A metering valve is placed between these diaphragms. A spring in the left side of the secondary servo section moves the metering valve to the right (open) when air pressure in both sides of the main servo section is the same. This happens when there is no airflow through the venturi. The metering valve moves to the left (closed) when pressure in the right side of the main servo section increases. This happens when there is an increase in air pressure at the base of the venturi. The metering valve is set up to move toward the closed position to prevent a surge of air from going into the air conditioning system. Such a surge of air could damage the air conditioning ducts. The air that leaves the servo controller goes to the pneumatic actuator. The air that is used to operate, both the servo controller and the pneumatic actuator come from the venturi.

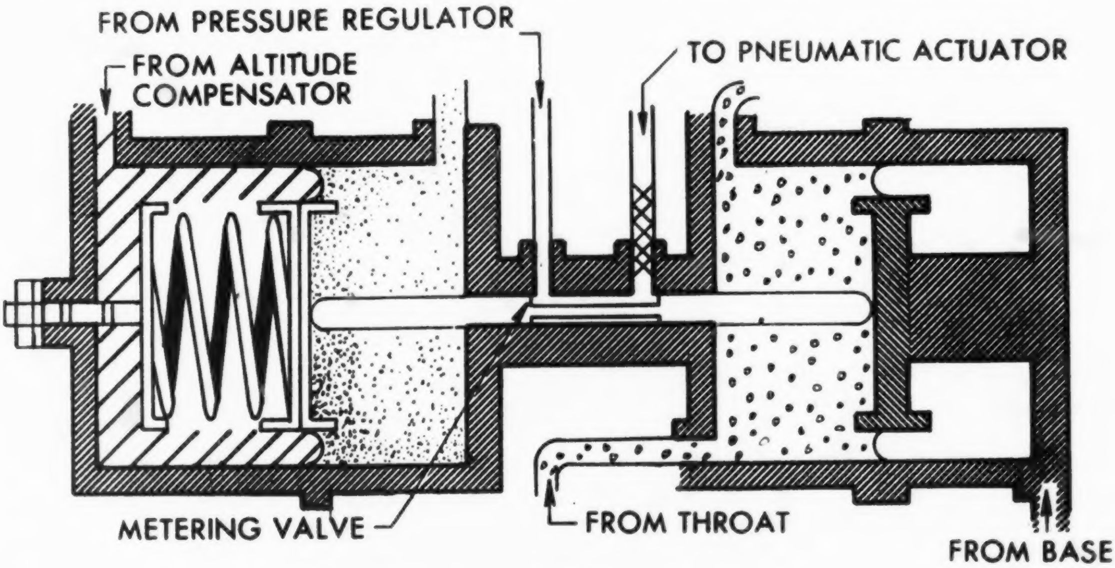

Figure 3. Servo Controller.

Use figures 1 and 3 as guides to pick the statements that describe the purpose or characteristics of the servo controller. Answer the statements as true (T) or false (F).

1. The metering valve of the servo controller controls the flow of air to the venturi.

2. The metering valve of the servo controller is controlled by differential pressure and spring force.

3. The servo controller receives air pressure from both the venturi throat and base.

4. When the metering valve is moved to the right it partially blocks the airflow to the pneumatic actuator.

Answers to Frame 3. 1. F 2. T 3. T 4. F

FRAME 4

The metering valve is moved to the right by the spring when there is no pressure in the system, or when pressure from the venturi is the same on both sides of the main servo diaphragm.

The metering valve is moved to the left when pressure at the throat of the venturi drops. The flow of air from the pressure regulator will now pass through the servo controller and into the pneumatic actuator. This flow of air is partially blocked by the metering valve.

From the right- hand column pick the statement that matches a component or part of a component in the left- hand column. Each response may be used only once.

1. Metering Valve.
2. Secondary Servo Spring.
3. Main Servo Diaphragm.
4. Venturi.
5. Servo Controller.

A. Senses differential pressure from the venturi.

B. Controls airflow to the Pneumatic Actuator.

C. Moves the metering valve of the servo controller to the right.

D. Provides differential pressure to the servo controller.

E. Restricts airflow to the pneumatic actuator when throat pressure of the venturi drops.

Answers to Frame 4. 1. E 2. C 3. A 4. D 5. B

FRAME 5

The pressure regulator, figure 1 (3), lowers the pressure of the air that is tapped off from the base of the venturi. The pressure regulator itself is a spring-loaded, diaphragm-actuated relief valve that reduces air pressure down to 12 to 35 psig. The air pressure varies depending on the supply pressure that is tapped off from the base. (The abbreviation "psig" stands for the pressure in pounds per square inch that can be measured on a gage.)

From the list of words provided at the bottom of the page, complete each of the statements concerning the venturi, servo controller, and pressure regulator.

1. Pressure for the control system of the airflow control and shutoff valve comes from the ____________ tap-off of the venturi.

2. The venturi sends air pressure to the ______________ ___________ section of the servo controller.

3. A pressure of 12 to 35 psig is kept in the control system by the ________________ _______________________.

4. Airflow to the pneumatic actuator is controlled by the ____________ ___________________________.

5. The pressure regulator is operated by spring force and a pneumatic ___________________________.

Select from the following the word or words to complete the

Pressure Regulator
Base
Diaphragm
Low Pressure
Servo Controller
Throat

Metering Valve
High Pressure
Main Servo
Secondary Servo
Venturi

Answers to Frame 5. 1. Base 2. Main Servo 3. Pressure Regulator

4. Servo Controller 5. Diaphragm

FRAME 6

Air pressure from the base tap-off of the venturi goes through the filter (9) where bits of dirt are removed before the air goes in the lower chamber of the pressure regulator. As pressure builds up in the lower chamber, it lifts the diaphragm up against the force of a spring that is pushing down from the top. As the diaphragm goes up, the relief poppet opens and dumps the high pressure from the control systems. The relief poppet is closed by the spring that pushes down from the top.

Use figure 1 as a guide to pick the statements that are true (T) or false (F).

1. Air for the pressure regulator comes from the throat of the venturi.

2. The pressure regulator keeps a constant pressure in the control system regardless of the supply pressure from the venturi.

3. The pressure regulator sends pressure directly to work the pneumatic actuator.

4. Air from the pressure regulator that moves the pneumatic actuator is controlled by the servo controller.

5. The servo controller controls actuating pressure in the control system.

Answers to Frame 6. 1. F 2. F 3. F 4. T 5. T

FRAME 7

Solenoid valve "A" (4) of the airflow control and shutoff valve is the ON-OFF control for this part. Solenoid valve "A" is a DC part that is moved by aircraft power. When the air conditioning system is shut down the valve will be energized closed. Solenoid valve "A" is spring loaded to the open position. For normal operation, power is not sent to the solenoid. Solenoid valve "A" is controlled by the main air conditioning switch.

Complete the statements by listing the word(s) in parentheses that make the statement true.

1. Solenoid valve "A" must be (energized; de-energized) to close the airflow control and shutoff valve.

2. If a power loss is experienced on the aircraft in flight, the airflow control and shutoff valve would (close; operate normally).

3. Solenoid valve "A" is (energized; de-energized) when the air conditioning system is in operation.

4. Solenoid valve "A" gets air straight from the (venturi; pressure regulator; servo controller).

5. When solenoid valve "A" is energized, pressure at the throat of the venturi is (more than; the same as; less than) pressure at the base of the venturi.

Answers to Frame 7. 1. energized 2. operate normally 3. de-energized 4. servo controller 5. the same as

FRAME 8

The pneumatic actuator (5) is a spring loaded, diaphragm operated device. It is hooked to a butterfly valve by linkage. The top half of the actuator is a pnuematic chamber. The bottom half has a vent to the atmosphere and has two springs. These springs force the diaphragm and linkage up to close the butterfly when air pressure is removed from the top side of the diaphragm. When air pressure from the servo controller goes through the de-energized solenoid valve "A" to the top half of the pneumatic actuator, the diaphragm and linkage are forced down. This will cause the butterfly valve to open. When solenoid valve "A" is energized, air pressure to the top half is shut off.

Use figure 1 as a guide, give the number in figure 1 that identifies each of the major components listed.

1. Pneumatic Actuator.
2. Servo Controller.
3. Solenoid Valve "A".
4. Venturi.
5. Pressure Regulator.
6. Filter.

Answers to Frame 8. 1. (5) 2. (2) 3. (4) 4. (1) 5. (3) 6. (9)

FRAME 9

The altitude compensator (6) is an aneroid controlled metering valve. The aneroid is an evacuated container that has a set internal pressure. With a rise in the altitude of the aircraft, the aneroid expands. At a set altitude, the aneroid will expand enough to let pressure from the control system to go in the left side of the secondary servo and force the diaphragm and metering valve to the right. This will let more air to flow to the pneumatic actuator and will cause the butterfly to open more and cause the flow of more air to the air conditioning package. On the other hand, as the aircraft comes down from high altitudes the aneroid contracts and the metering valve starts to close, thus reducing airflow to the secondary servo. The altitude compensator works with the servo controller to maintain a constant pneumatic pressure to give a constant air output.

Answer the statements as true (T) or false (F).

1. The altitude compensator will cause an increase in the flow of air to the air conditioning package at high altitudes.

2. As aircraft altitude increases, the aneroid in the altitude compensator contracts.

3. The metering valve of the altitude compensator controls the flow of air to the secondary servo diaphragm.

4. As the aneroid expands, the flow of air to the air conditioning package is reduced.

5. Whem the aneroid of the altitude compensator has expanded, the butterfly valve of the airflow control and shutoff valve will open.

Answers to Frame 9. 1. T 2. F 3. T 4. F 5. T

FRAME 10

Solenoid valve "B" is a valve that is usually spring loaded closed. It is energized open only during ground operation and its function is to reduce the amount of air that flows to the cabin air conditioning system. During ground operation, a gas turbine compressor (GTC) is used to run the ATM for electrical power and to run the air conditioning system Since the gas turbine compressor cannot produce as much air as the aircraft engines, the airflow control and shutoff valve will reduce air flow to the air conditioning system so that the majority of the air produced by the GTC can be used to run the ATM.

When solenoid valve "B" is energized, air is vented from the left side of the main servo section. The amount of air that is vented is controlled by an adjustment screw (11). As the air is vented, the higher pressure on the right side of the main servo diaphragm will force the metering valve to the left, restricting the amount of air to the pneumatic actuator. With less air, the pneumatic actuator will move up, causing the butterfly to move toward the closed position and reducing the amount of air to the air conditioning system.

Answer the statements as true (T) or false (F). Use the foldout if necessary.

1. When the gas turbine compressor is used as the source of air for system operation, solenoid valve "B" is de-energized.

2. When solenoid valve "B" is energized, the metering valve of the servo controller will move to the left.

3. When in the ground schedule operation of the air conditioning system, solenoid "B" is energized.

4. When solenoid valve "B" is energized, the flow of air to the air conditioning system is stopped.

Answers to Frame 10.   1. F   2. T   3. T   4. T

FRAME 11

The manual override control (8) is an emergency system. It will start or stop the flow of air to the pneumatic actuator should solenoid valve "A" fail in the closed position. Air for this operation comes from the pressure regulator through the servo controller. An air line is used to send air to the pneumatic actuator. The manual override control is a cam and poppet that is moved by a TELEFLEX cable. When the handle of the teleflex control is placed to the open position, the cam is turned and will push on the right-hand poppet and cause the poppet to open. Air is then sent to tht top side of the pneumatic actuator. This will cause the butterfly valve to open. Once the butterfly is open the flow of air is metered by the servo controller to the pneumatic actuator. This maintains a constant flow of air to the air conditioning system. To shut the system down (OFF) the remote control is placed to the closed position; again, the cam is turned, and will let the right-hand poppet close as the left poppet is opened by the cam. With the left-hand poppet open air is dumped from the pneumatic actuator top side and the butterfly valve will close. This stops the flow of air to the air doncitioning system.

Use figure 2 as a guide to answer the statements as true (T) or false (F).

1. A remote controlled cam and two poppets control the pneumatic actuator when solenoid valve "A" fails in the closed position.

2. The airflow control and shutoff valve will not automatically keep a calibrated airflow when the manual override control is being used.

3. The manual override control bypasses solenoid valve "A".

4. The servo controller will meter the flow of air to the pneumatic actuator when the manual control is being used.

5. The teleflex cable directly controls the poppet valves of the manual override control.

Answers to Frame 11. 1. T 2. F 3. T 4. T 5. F

FRAME 12

From the right-hand column, pick the statement that best describes the purpose or operation of each of the components in the left-hand column.

1. Venturi
2. Solenoid Valve "A"
3. Servo Controller
4. Manual Override Control
5. Pressure Regulator
6. Solenoid Valve "B"
7. Altitude Compensator
8. Pneumatic Actuator

A. Increases airflow to the air conditioning package at high altitude.

B. Provides differential pressure for the control system.

C. Controls airflow to the pneumatic actuator when solenoid valve "A" is inoperative.

D. Meters airflow to the pneumatic actuator.

E. Reduces pressure in the control system.

F. Controls the amount of airflow to the air conditioning system.

G. Turns the air conditioning system ON and OFF.

H. Is used to control system operation when the aircraft is on the ground.

Answers to Frame 12. 1. B 2. G 3. D 4. C 5. E 6. H 7. A 8. F

FRAME 13

Now, just as a review, write the names of the major components that corresponds to the numbers in parentheses. Use figure 4, if you must, to help you name all of them.

1. (8) ______________________

2. (2) ______________________

3. (6) ______________________

4. (3) ______________________

5. (5) ______________________

6. (9) ______________________

7. (1) ______________________

8. (4) ______________________

9. (7) ______________________

You can check your responses to this frame at the top of the next page.

Answers to Frame 13.

1. Manual Override Control
2. Servo Controller
3. Altitude Compensator
4. Pressure Regulator
5. Pneumatic Actuator
6. Filter
7. Venturi
8. Solenoid Valve "A"
9. Solenoid Valve "B"

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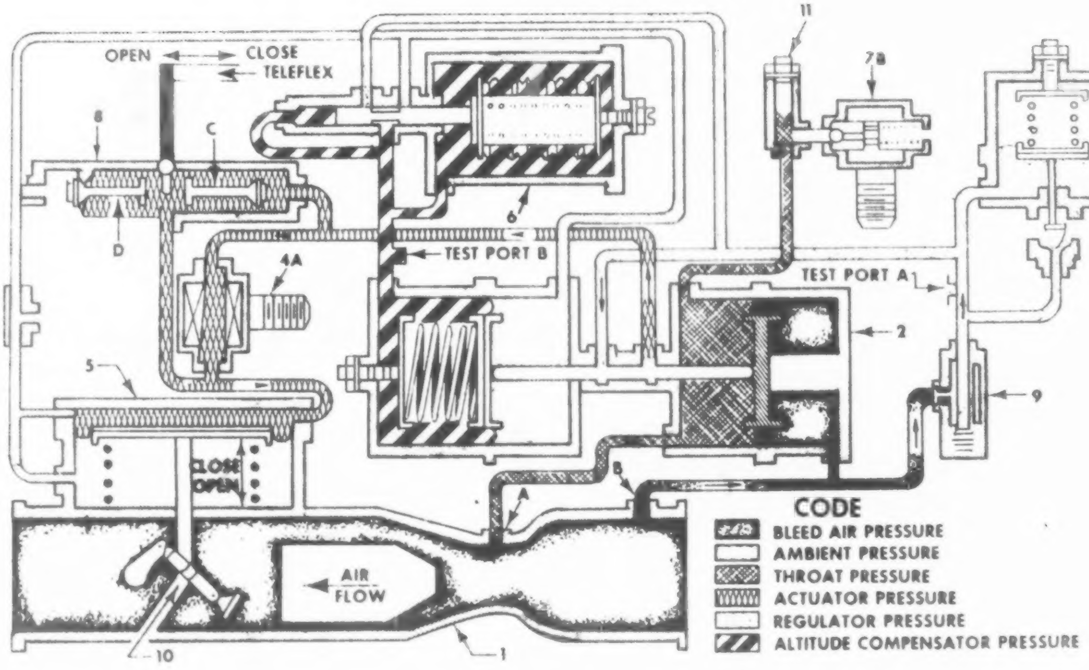
OPEN
CLOSE
TELEFLEX
11
7B
8
C
3
D
6
TEST PORT B
4A
TEST PORT A
2
5
9
CLOSE
OPEN
B
A
AIR FLOW
10
1
CODE
BLEED AIR PRESSURE
AMBIENT PRESSURE
THROAT PRESSURE
ACTUATOR PRESSURE
REGULATOR PRESSURE
ALTITUDE COMPENSATOR PRESSURE

Figure 4. Airflow Control and Shutoff Valve.

WORKBOOK

3ABR42331-WB-312A

Technical Training

Aircraft Environmental System Repairman

BENCH CHECK AIRFLOW REGULATOR

14 May 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: N/A

Environmental Pneudraulics Branch
Chanute AFB, Illinois

3ABR42331-WB-312A

BENCH CHECK AIRFLOW REGULATOR

OBJECTIVE

Using the applicable TO, electrical/pneumatic component trainer and the necessary tools, bench check and repair an airflow control and shutoff valve with a maximum of two instructor assists.

EQUIPMENT

Airflow Regulator
Electric Pneumatic
  Trainer (3038)
4" Screwdriver
1/2" x 3/8" Open End Wrench
TO Index 0-1-1-3
TO Index 0-1-15

INSTRUCTIONS

This workbook is in eight sections. The first one is to familiarize you again with the 3038 trainer. Section two has you use a diagram and TO to identify and inspect the components of an airflow regulator. Section eight has you document the bench check action on an AFTO Form 349.

You will be required to use TO indexes to find the correct tech order number for the valve you will bench check. Under the heading "EQUIPMENT" you can find the TO index number and the regulator part number. Using this information you will be able to find the correct tech order for the regulator. All indexes and overhaul tech orders are located in the TO file.

Section 1. ELECTRIC PNEUMATIC TESTER TRAINER (3038)

1. Use figure 1 to familiarize yourself with the trainer by locating the listed parts. You will be using the trainer to bench check the airflow regulator.

a. Voltage adjustment potentiometer (A). This is used to adjust the DC voltage on the trainer.

b. Low capacity orifice flowmeter (B). An orifice is put in this portion of the tester so that a differential pressure may be kept at the manometers.

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  3370 TCHTG/TTGU-P - 1000; DAV - 1

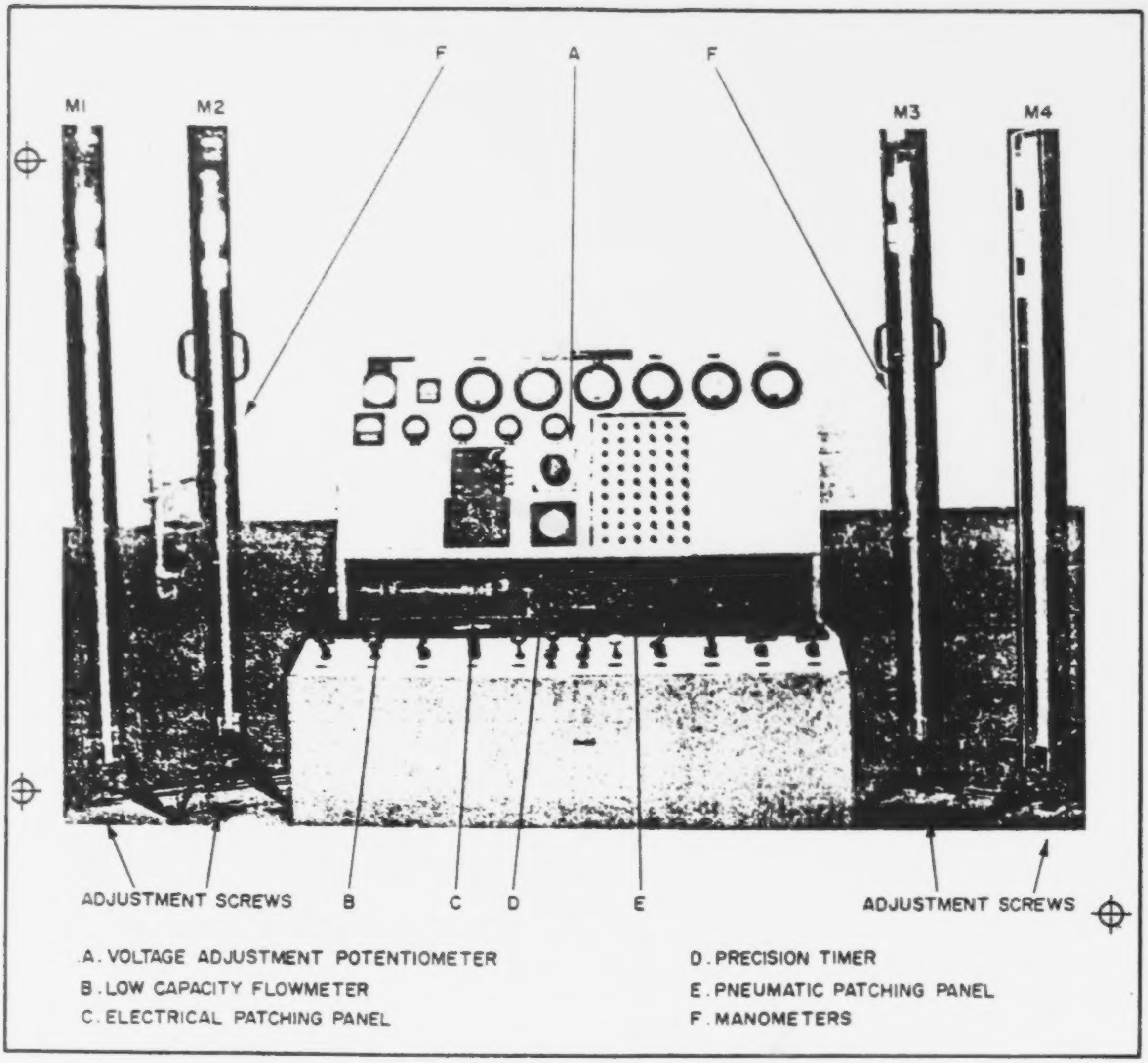

F
A
F
M1
M2
M3
M4
ADJUSTMENT SCREWS
B
C
D
E
ADJUSTMENT SCREWS
A. VOLTAGE ADJUSTMENT POTENTIOMETER
B. LOW CAPACITY FLOWMETER
C. ELECTRICAL PATCHING PANEL
D. PRECISION TIMER
E. PNEUMATIC PATCHING PANEL
F. MANOMETERS

Figure 1. Trainer No. 3038 - Electric Pneumatic Tester.

c. Electrical patching panel (C). Electrical wires will be hooked from this panel to the valve under test.

d. Precision timer (D). Gives the cycling time of the part under test. Press down on the black lever to reset before each test.

e. Pneumatic patching panel (E). Hoses will be hooked from this panel to the valve under test.

f. Manometers (F). These are pressure measuring devices.

Section 2. IDENTIFY AND INSPECT THE COMPONENTS OF AN AIRFLOW REGULATOR

1. Go to locker 2 and get one airflow regulator, part number 106616.

2. Set the valve on the trainer so the large end of the venturi is to your right, and the valve position indicator is facing you. Your view of the valve should match the view in figure 7A.

3. Use figure 7A to find each part on the valve. As you find each part put a checkmark in the blank on your response sheet.

a. ____________ Adjustment screw "A"

b. ____________ Test port "A"

c. ____________ Adjustment screw "B"

d. ____________ Adjustment screw "E"

e. ____________ Position indicator

f. ____________ Venturi

g. ____________ Test port "B"

h. ____________ Altitude sensing port

4. Get a TO index 0-1-15 from the TO file. Turn to the table of contents located in the front of the TO. Research the airflow regulator valve, part number (P/N) 106616 to find the correct TO which covers "Overhaul Instructions." Answer the following questions on your response sheet.

a. The TO number is ______________________________.

b. The basic date of this TO is ____________________.

c. The change date of this TO is ____________________.

5. From the information provided in the TO, write down the inspection requirements for the airflow regulator.

a. Inspect all parts for evidence of ____________________.

b. Inspect all metering orifices and internal air passages for ____
____.

c. Inspect all _________________________ and _______________ parts for ____.

Section 3. ALTITUDE COMPENSATOR BELLOWS PRESET ADJUSTMENT

1. You are now ready to start calibrating the airflow regulator. Carefully follow each step of the calibration process. If you have any difficulty, get the instructor. The first adjustment is the altitude compensator bellows preset adjustment.

2. Look at figure 7A and find adjustment screw "B." By turning adjustment screw "B" you are adjusting the position of the bellows in the altitude compensator. The altitude compensator is an aneroid controlle metering valve. The job of the compensator is to open the valve butterfly to let more air flow through the valve as the aircraft altitude increases. The compensator is made of a bellows, spring, and an altitude compensator adjustment screw "B."

3. Loosen the locknut that holds adjustment screw "B" in place. Turn adjustment screw "B" clockwise (↻) until it bottoms (stops turning). When it hits bottom, DO NOT FORCE IT ANY TIGHTER.

4. Turn adjusting screw "B" exactly 3 1/2 turns counterclockwise (↺). Turn the locknut. Be sure that you do not move adjustment screw "B." This adjustment presets the altitude compensator bellows.

Section 4. AIR PRESSURE REGULATOR CALIBRATION AND ELECTRICAL CHECK

1. You will now set the air pressure regulator section of the airflow regulator. Look at figure 7A and find adjustment screw "A." The air pressure regulator reduces air pressure in the control air system of the airflow regulator (schematic diagram, figure 7B). The air pressure reguator is a relief valve. Operation of the regulator is controlled by a spring loaded diaphragm.

2. The electrical wires and pneumatic hoses used for connecting the valve to the trainer are in the bottom of the trainer.

3. Using the electrical wires, connect the valve to the trainer electrical patching panel according to the steps below. As you do each of the steps, place a checkmark in the blank on your response sheet.

a. ____________ F on the trainer to A on the valve cannon plug

b. ____________ G on the trainer to B on the valve cannon plug

c. ____________ R on the trainer to C on the valve cannon plug

d. ____________ Turn valve V3 on the trainer clockwise to the OFF position.

4. The electrical wires will stay connected throughout the entire bench check.

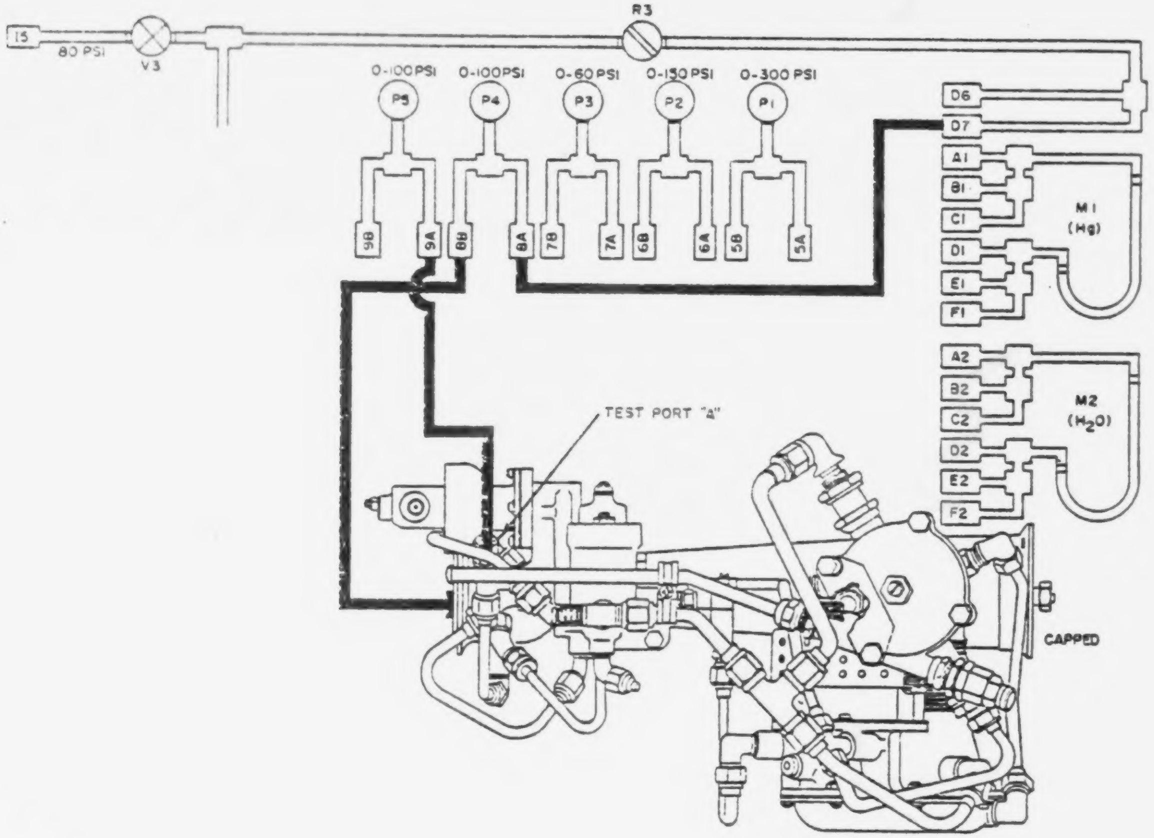

15
80 PSI
V3
R3
0-100PSI
P5
0-100PSI
P4
0-60 PSI
P3
0-150 PSI
P2
0-300 PSI
P1
9B
9A
8B
8A
7B
7A
6B
6A
5B
5A
D6
D7
A1
B1
C1
D1
E1
F1
M1
(Hg)
A2
B2
C2
D2
E2
F2
M2
(H_2O)
TEST PORT "A"
CAPPED

Figure 2

5. Look at figure 2 when connecting the pneumatic hoses to the trainer pneumatic patching panel and to the valve. The hoses are shown by heavy black lines. Check off each item on your response sheet.

a. ____________ D7 to 8A

b. ____________ 8B to the inlet side of the valve

c. ____________ Test port A to 9A

d. ____________ Take the cap from the altitude sensing port (refer to figure 7A).

e. ____________ HAVE THE INSTRUCTOR CHECK YOUR CONNECTIONS.

f. ____________ Plug the 3 trainer power cords in the receptacles on the wall behind the trainer.

g. ____________ Place switch S-1 on the trainer to the ON position.

h. ____________ Place switch S-2 to the 3 position. This puts 28V DC to solenoid A.

Section 3. ALTITUDE COMPENSATOR BELLOWS PRESET ADJUSTMENT

1. You are now ready to start calibrating the airflow regulator. Carefully follow each step of the calibration process. If you have any difficulty, get the instructor. The first adjustment is the altitude compensator bellows preset adjustment.

2. Look at figure 7A and find adjustment screw "B." By turning adjustment screw "B" you are adjusting the position of the bellows in the altitude compensator. The altitude compensator is an aneroid controlle metering valve. The job of the compensator is to open the valve butterfly to let more air flow through the valve as the aircraft altitude increases. The compensator is made of a bellows, spring, and an altitude compensator adjustment screw "B."

3. Loosen the locknut that holds adjustment screw "B" in place. Turn adjustment screw "B" clockwise (↷) until it bottoms (stops turning). When it hits bottom, DO NOT FORCE IT ANY TIGHTER.

4. Turn adjusting screw "B" exactly 3 1/2 turns counterclockwise (↶). Turn the locknut. Be sure that you do not move adjustment screw "B." This adjustment presets the altitude compensator bellows.

Section 4. AIR PRESSURE REGULATOR CALIBRATION AND ELECTRICAL CHECK

1. You will now set the air pressure regulator section of the airflow regulator. Look at figure 7A and find adjustment screw "A." The air pressure regulator reduces air pressure in the control air system of the airflow regulator (schematic diagram, figure 7B). The air pressure reguator is a relief valve. Operation of the regulator is controlled by a spring loaded diaphragm.

2. The electrical wires and pneumatic hoses used for connecting the valve to the trainer are in the bottom of the trainer.

3. Using the electrical wires, connect the valve to the trainer electrical patching panel according to the steps below. As you do each of the steps, place a checkmark in the blank on your response sheet.

a. ____________ F on the trainer to A on the valve cannon plug

b. ____________ G on the trainer to B on the valve cannon plug

c. ____________ R on the trainer to C on the valve cannon plug

d. ____________ Turn valve V3 on the trainer clockwise to the OFF position.

4. The electrical wires will stay connected throughout the entire bench check.

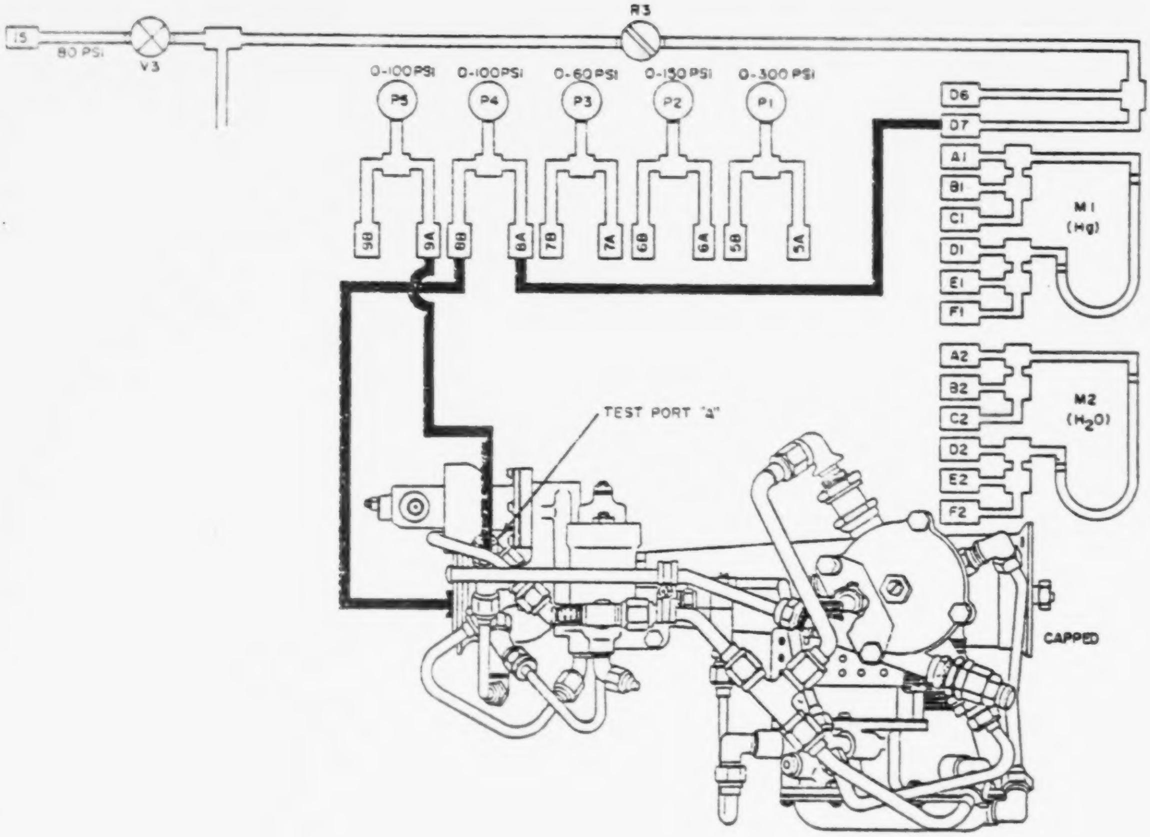

R3
15
80 PSI
V3
0-100PSI
0-100PSI
0-60PSI
0-150PSI
0-300PSI
P5
P4
P3
P2
P1
9B
9A
8B
8A
7B
7A
6B
6A
5B
5A
D6
D7
A1
B1
C1
D1
E1
F1
M1
(Hg)
A2
B2
C2
D2
E2
F2
M2
(H2O)
TEST PORT "A"
CAPPED

Figure 2

5. Look at figure 2 when connecting the pneumatic hoses to the trainer pneumatic patching panel and to the valve. The hoses are shown by heavy black lines. Check off each item on your response sheet.

a. ____________ D7 to 8A

b. ____________ 8B to the inlet side of the valve

c. ____________ Test port A to 9A

d. ____________ Take the cap from the altitude sensing port (refer to figure 7A).

e. ____________ HAVE THE INSTRUCTOR CHECK YOUR CONNECTIONS.

f. ____________ Plug the 3 trainer power cords in the receptacles on the wall behind the trainer.

g. ____________ Place switch S-1 on the trainer to the ON position.

h. ____________ Place switch S-2 to the 3 position. This puts 28V DC to solenoid A.

i. ____________ Turn V3 counterclockwise until it is full open.

j. ____________ Turn regulator R3 clockwise until gage P-4 reads 15 psig.

k. ____________ Loosen the locknut on adjustment screw A and adjust the screw until 12 psig shows on gage P-5. Tighten the locknut. Be careful not to move adjusting screw A. Adjustment screw A sets the air pressure regulator. We now have 12 psi in the valve control air system.

l. ____________ Turn R3 counterclockwise until 10 psig is read on gage P-4.

Section 5. THRUST TEST

1. The thrust test is done to see whether or not the butterfly is moving to the full closed position. Do these steps to make the thrust test and check them off on your response sheet.

a. __________ Check the valve position indicator. It should read CLOSED.

b. __________ Turn switch S-2 to 1 position. This deenergizes solenoid A.

c. __________ Check the valve position indicator. It should read OPEN.

d. __________ Turn switch S-2 to 3 position. This energizes solenoid A.

e. __________ Check the valve position indicator. It should read CLOSED.

f. __________ IF THE VALVE INDICATOR DOES NOT READ "OPEN" OR "CLOSED", GET THE INSTRUCTOR.

2. The valve should have opened and closed with a minimum pressure of 10 psi. If not, adjustment to screw "E" would be made (figure 7A).

a. __________ Turn regulator R3 counterclockwise until gage P-4 reads 0 psig.

b. __________ Remove all the pneumatic hoses.

c. __________ Place the cap on test port A.

d. __________ DO NOT REMOVE THE ELECTRICAL WIRES.

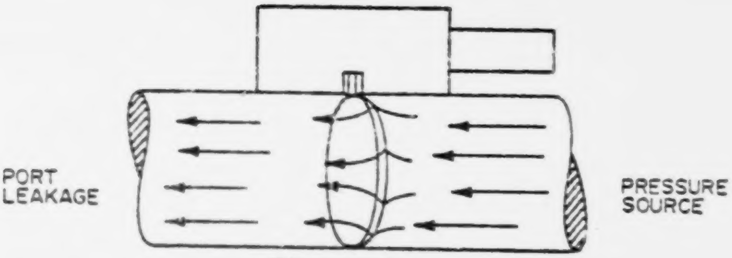

PORT LEAKAGE
PRESSURE SOURCE

Figure 3

Section 6. PORT LEAKAGE CHECK

1. In the next step, you will check for port leakage. Port leakage is leakage past the valve butterfly with the valve in the CLOSED position. Figure 3 is an illustration of port leakage.

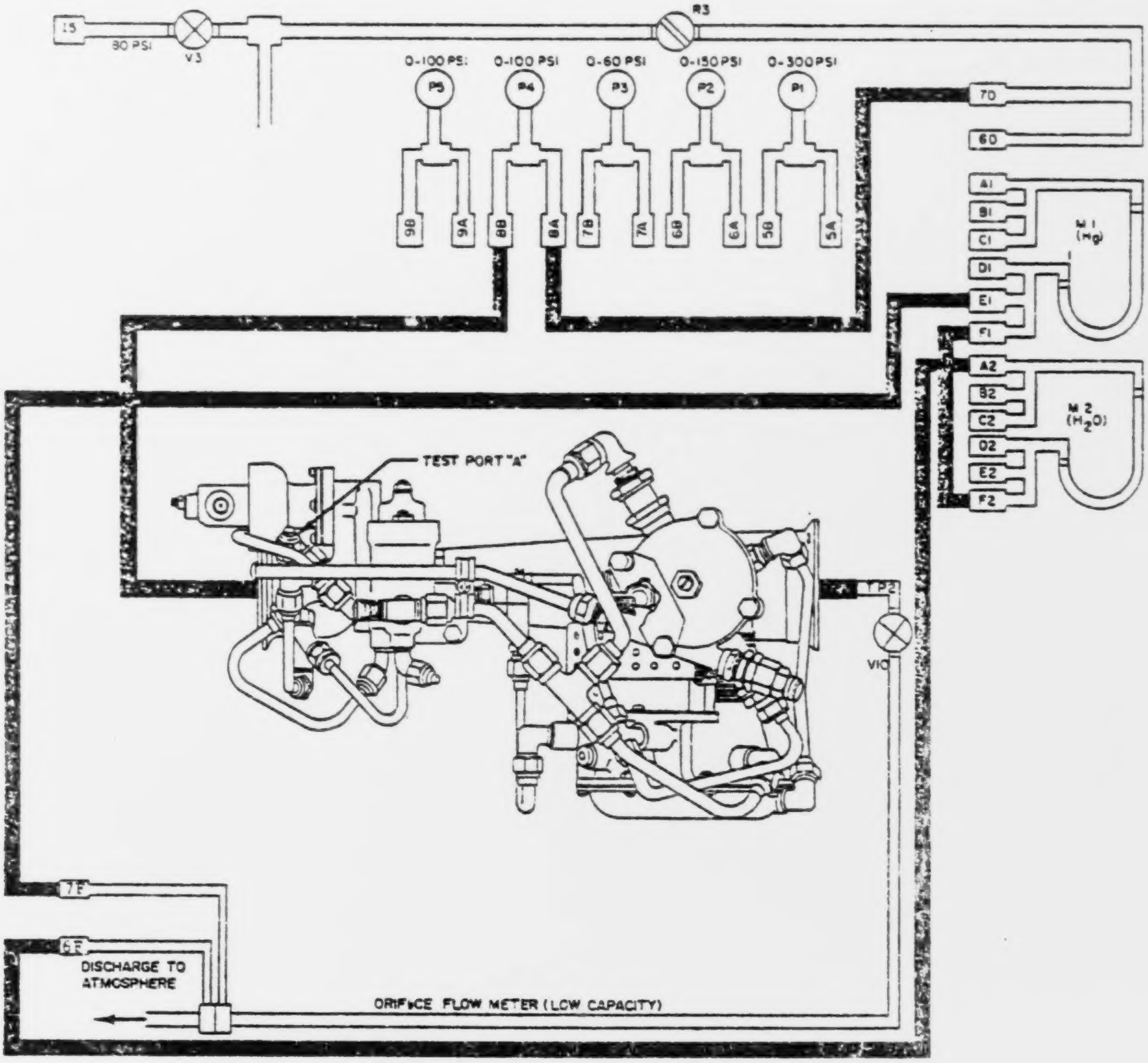

15
80 PSI
V3
R3
0-100 PSI
0-100 PSI
0-60 PSI
0-150 PSI
0-300 PSI
P5
P4
P3
P2
P1
9B
9A
8B
8A
7B
7A
6B
6A
5B
5A
7D
6D
A1
B1
C1
D1
E1
F1
M 1 (Hg)
A2
B2
C2
D2
E2
F2
M 2 (H_2O)
TEST PORT "A"
TP2
V10
7F
6F
DISCHARGE TO ATMOSPHERE
ORIFICE FLOW METER (LOW CAPACITY)

Figure 4

2. Connect the pneumatic hoses, shown in figure 4 by the heavy black lines, to the trainer pneumatic patching panel and the valve. Check off each item and make your responses on the response sheet.

a. __________ 7D to 8A

b. __________ 8B to the valve inlet

c. __________ TP2 to the valve outlet

d. __________ 6F to A2

e. __________ 7F to E1

f. __________ F1 to F2

g. __________ Place the M-1 manometer on the inches of mercury (Hg) scale. This scale starts at 28 inches.

h. __________ Set the top of the Hg bubble to 30 inches.

i. __________ Place the M-2 manometer on the inches of water (H_2O) scale so that the bottom of the bubble is on zero.

j. __________ Take the steel cap off the 1 1/4 inch pipe at the left side of the trainer. This opens the outflow section of the .150 orifice.

k. __________ If you have followed the instructions carefully up to now, the position indicator on the valve should be at the full CLOSED position.

l. __________ Check the position of switch S-2. It must be in position 3.

m. __________ Slowly turn valve V10 to the full open position. This allows a path for exhaust air leaving the shutoff valve.

n. __________ Slowly turn valve V3 to the full open position. This allows air pressure to flow to the trainer.

Note: Using a grease pencil, trace the following steps on the airflow schematic located to the right of the pneumatic fittings on the 3038 trainer.

o. Turn R-3 clockwise until 50 psig is read on pressure gage P-4. This allows air pressure to pass through connection 7D, through pressure gage P-4, then to the valve. Even though the valve is closed, some air leaks through and passes through V10, TP2, and then to the orifice. Air pressure from the upstream side of the orifice passes through connection 7F to E1, into the bottom of M-1, and at the same time through fitting F1 to F2 and into the bottom of M-2. The mercury manometer (M-1) is now reading the absolute pressure passing through the valve and on to the orifice. This high pressure is also pushing the water up in manometer M-2. After the air passes through the orifice, the presssure will drop due to turbulence caused by the restriction. This low pressure flows through fitting 6F to A2 and into the top of manometer M-2 and tries to push the water down. The point where the two pressures meet and stabilize in M2 is the point where the differential pressure is taken. To determine if the valve is leaking excessively, write down the readings taken from M-1 and M-2 at this time.

3. What is the reading on the M-1 manometer? ____________________

4. What is the reading on the M-2 manometer? ____________________

a. ____________ Turn R-3 counterclockwise until 0 psig is read on gage P-4.

5. The next step is to see if the leakage of your valve is within normal limits. The amount of air passing the closed butterfly is measured in pounds per minute (PPM). The formula used to determine the amount of leakage is:

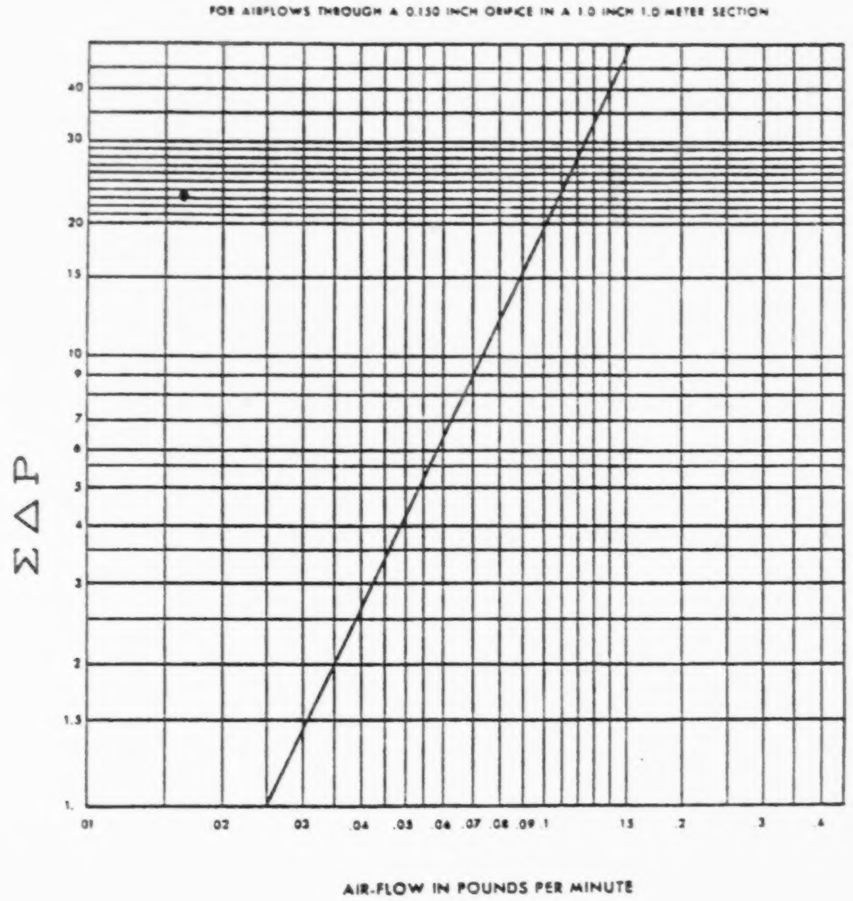
$$\Sigma \Delta P = \frac{17.35 \times P_1}{T_1 + 460} \Delta P$$

P_1 is the M-1 manometer reading.

P is the M-2 manometer reading.

T_1 is the temperature of the air.

6. Read the lab thermometer. The temperature is ____________________.



Note: Each shop is supplied with the correct graph for the size orifice being used.

Figure 5

7. After you have determined ΣΔP, use the conversion chart (figure 5) to convert ΣΔP to airflow in pounds per minute (PPM).

8. Your valve is leaking ____________ PPM.

9. Turn to the "Test and Calibration Instructions" section in the TO. Find the allowable port leakage. Leakage must not be more than ____________ PPM.

10. Is your valve leaking too much? ____________ If the valve leaks too much, tell the instructor.

a. ____________ Remove all pneumatic hoses.

b. ____________ DO NOT REMOVE THE ELECTRICAL WIRES.

Section 7. BELLOWS PRESSURE CHECK

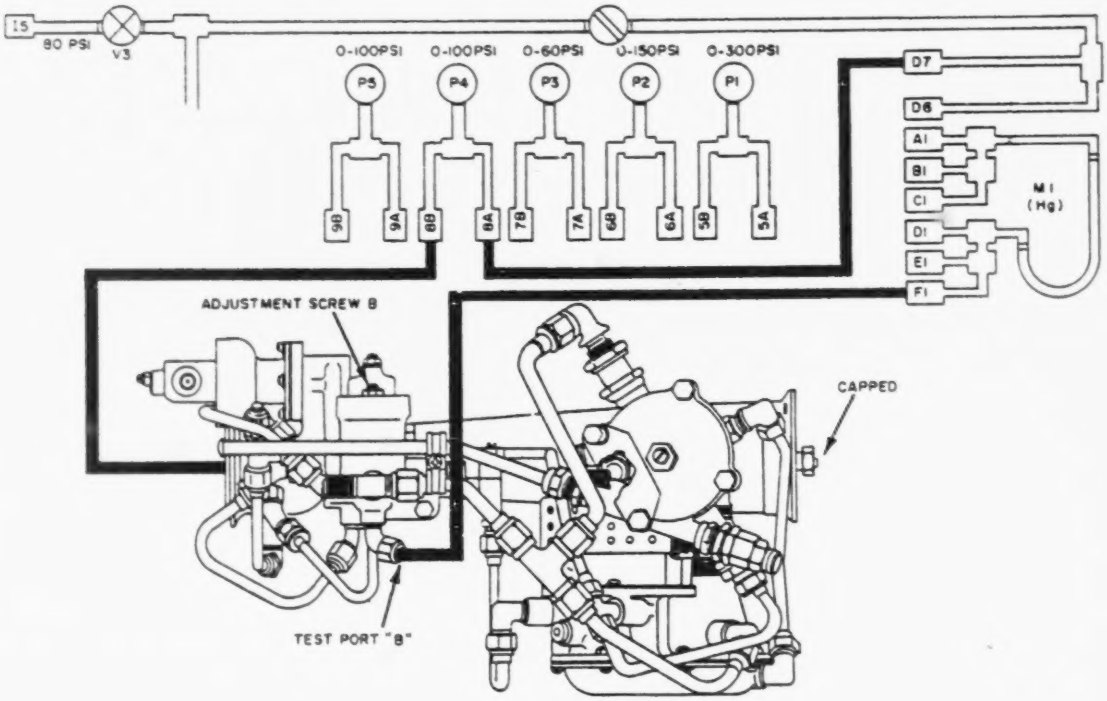

IS
80 PSI
V3
0-100PSI
0-100PSI
0-60PSI
0-150PSI
0-300PSI
P5
P4
P3
P2
P1
9B
9A
8B
8A
7B
7A
6B
6A
5B
5A
D7
D6
A1
B1
C1
D1
E1
F1
M1 (Hg)
ADJUSTMENT SCREW B
CAPPED
TEST PORT "B"

Figure 6

1. The final check you will make on the valve is the bellows pressure check. The bellows keep a proper flow of air through the valve from ground level up to the operating altitude. Look at figure 6 to find test port B and adjusting screw B. Connect the pneumatic hoses shown by the heavy black lines. Check off each item on your response sheet.

a. ____________ D7 to 8A.

b. ____________ 8B to the inlet of the valve.

c. ____________ F1 to test port B of the valve.

d. ____________ Open valve V-2.

e. ____________ Refer to the following steps and, using a grease pencil, trace the airflow on the trainer schematic.

Turn regulator R-3 until 50 psig is read on gage P-4. This allows air pressure to pass through D7, through gage P-4, and on to the inlet side of the valve. With the valve in the closed position and the outlet side capped, there will be no airflow through the valve.

f. ____________ Loosen the locknut on adjustment screw "B." This allows air pressure to enter the bellows chamber and pass through test port "B", and on to the bottom of M-1 through fitting F-1. Next, turn adjustment screw "B" clockwise or counterclockwise until manometer M-1 reads 33 Hg. Tighten the locknut and be careful NOT to move the adjustment screw.

2. Shutdown procedures.

a. ______________ Remove all pneumatic hoses and plug them. Place them neatly in the bottom of the trainer.

b. ______________ Remove all electrical wires and place them neatly in the bottom of the trainer.

c. ______________ Put the steel cap on the 1 1/4 inch pipe at the left side of the trainer.

d. ______________ Unplug the trainer and lay the wires across the work bench part of the trainer.

e. ______________ Cap all trainer outlets.

f. ______________ Replace the caps on the valve.

g. ______________ Put the regulator back in locker No. 2.

Section 8. MAINTENANCE DOCUMENTATION

Now that you are done bench checking the airflow regulator, you have to do the paperwork. Get an AFTO Form 349 from the door on locker #2. Remove TO Index 0-1-1-3 from the TO file. Look in the index to find the work unit code manual for the model C-130 series A. Using the code manual and the information below, complete the AFTO Form 349 for bench checking the airflow regulator. When you have completed the form, have the instructor check it.

Job Control Number ----------------------1180027
Work Center ------------------------------A92EJ
ID Number --------------------------------CA3476
Priority ---------------------------------3
Location ---------------------------------Shop
Type Maintenance ------------------------Unscheduled
When Discovered -------------------------Minor Inspection

Note: Bench checking requires only one line entry on AFTO Form 349.

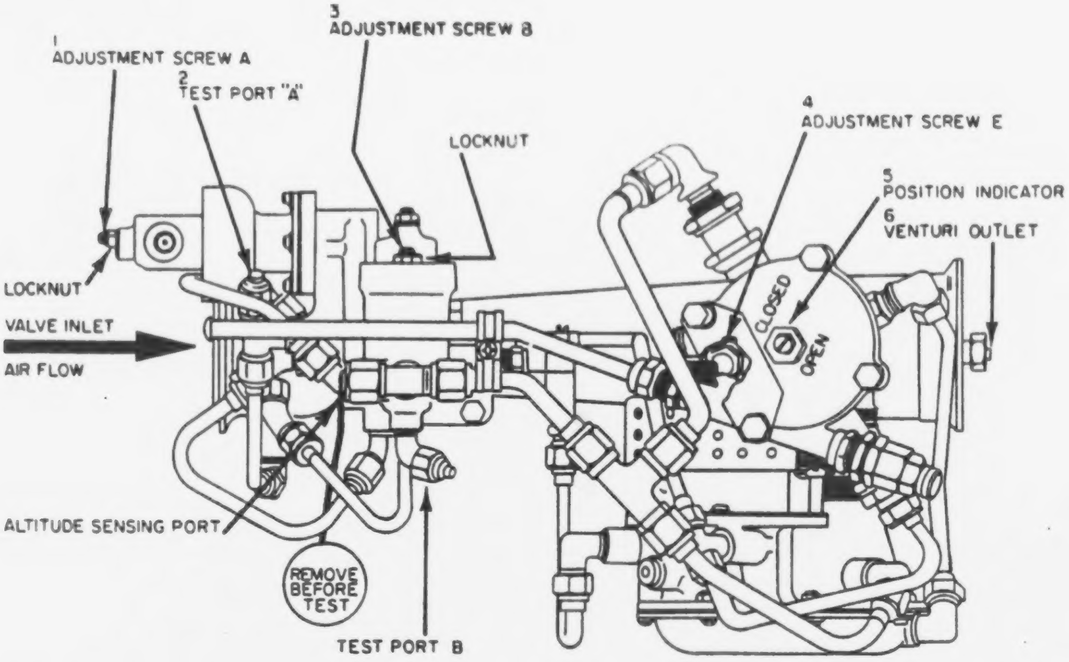

1
ADJUSTMENT SCREW A
2
TEST PORT "A"
3
ADJUSTMENT SCREW B
LOCKNUT
4
ADJUSTMENT SCREW E
5
POSITION INDICATOR
6
VENTURI OUTLET
LOCKNUT
VALVE INLET
AIR FLOW
CLOSED
OPEN
ALTITUDE SENSING PORT
REMOVE BEFORE TEST
TEST PORT B

Figure 7A. Airflow Regulator

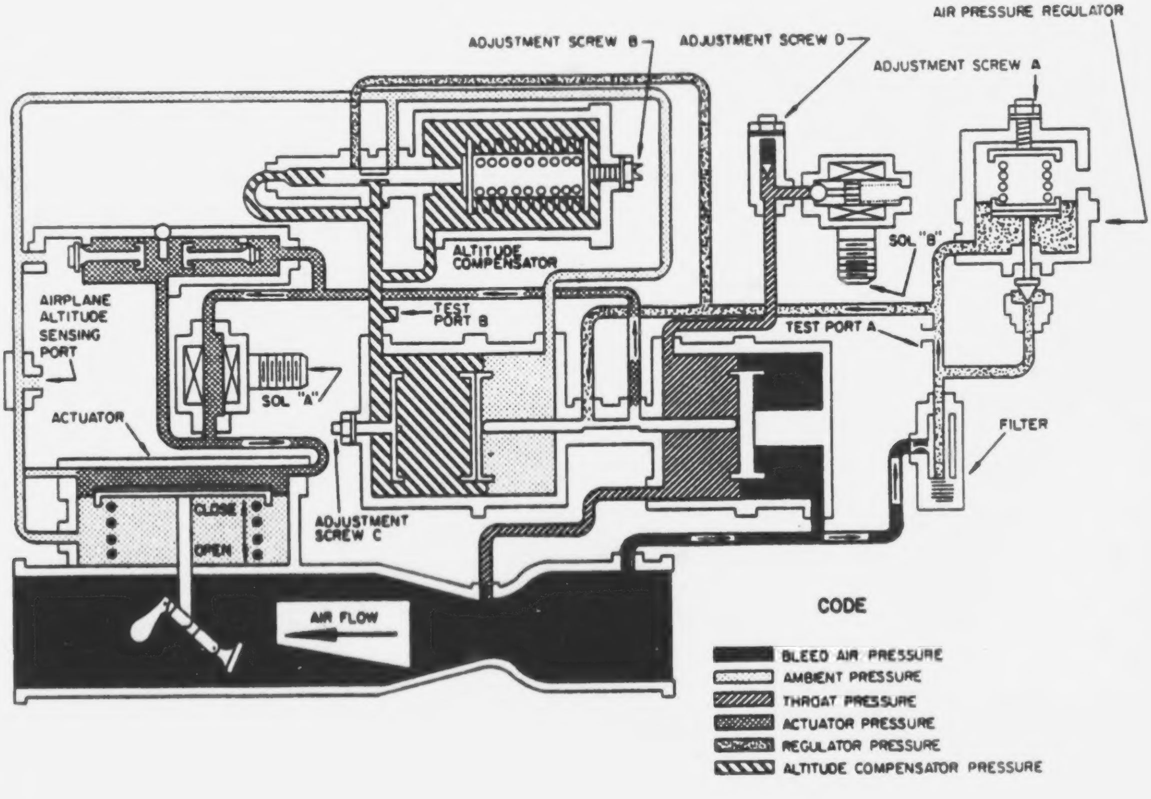

AIR PRESSURE REGULATOR
ADJUSTMENT SCREW B
ADJUSTMENT SCREW D
ADJUSTMENT SCREW A
ALTITUDE COMPENSATOR
SOL "B"
AIRPLANE ALTITUDE SENSING PORT
TEST PORT B
TEST PORT A
SOL "A"
ACTUATOR
FILTER
CLOSE
OPEN
ADJUSTMENT SCREW C
AIR FLOW
CODE
BLEED AIR PRESSURE
AMBIENT PRESSURE
THROAT PRESSURE
ACTUATOR PRESSURE
REGULATOR PRESSURE
ALTITUDE COMPENSATOR PRESSURE

Figure 7B. Regulator Schematic Diagram.

__________ Instructor's initials for first instructor assist.

__________ Instructor's initials for second instructor assist.

__________ Instructor's initials for third instructor assist which is failing.

__________ Instructor's initials for progression and satisfactory completion of this progress report.

PROGRAMMED TEXT
3ABR42331-PT-313

Technical Training

Aircraft Environmental Systems Mechanic

PRINCIPLES OF ANTI-G SYSTEM

11 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 9.6

BEST COPY AVAILABLE

OBJECTIVE

Relate major components of the Anti-G suit valve to their operations with 80% accuracy.

INSTRUCTIONS

This text presents information in small steps called "frames." After each step you are asked to select a correct statement. DO NOT MARK IN THIS TEXT. The correct answers may be found on the top of the next even numbered page. If your answer is correct, go to the next frame; if you are wrong, read the frame again. As you read the text, the Anti-G valves will be available for you to see and inspect.

Supersedes 3ABR42231-PT-313, 12 November 1975.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; DAV - 1

Because of the speed of jet aircraft, great forces and strains are experienced by the pilot. On level flights there is no limit to the speed that pilots can endure. But in loops, turns, and climbs, forces on the pilot's body are more than he can endure. Centrifugal force (G) is that force which pulls outward from the center of rotation. This force is "G" force. The unit measure is called a "G." Sitting in an aircraft on the flight line, your weight on the seat is the force of gravity. This force is equal to 1 G, or equal to the weight of your body. If you sat on a scale during level flight, you would notice that your weight would be normal. But during maneuvers, your weight would become more (indicating a positive "G") or less (indicating a negative "G"). This would depend on the maneuver. You can see that the G force can be positive or negative. If the force acts to hold you down in the seat (figure 1) it is a positive "G." However, if the force tends to lift you from the seat, it would be a negative "G."

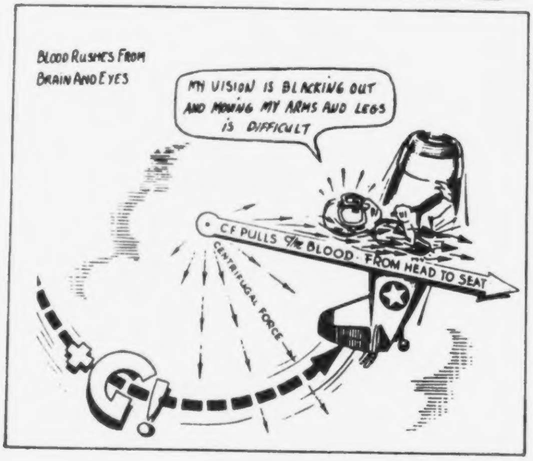

BLOOD RUSHES FROM BRAIN AND EYES
MY VISION IS BLACKING OUT AND MOVING MY ARMS AND LEGS IS DIFFICULT
CF PULLS THE BLOOD FROM HEAD TO SEAT
CENTRIFUGAL FORCE
+G!

Figure 1. Effects of Positive G Forces.

Answer the statements as true (T) or false (F).

1. Centrifugal force pulls outward from the center of rotation.

2. A G force is a unit of measure for centrifugal force.

3. Sitting in an aircraft on the flight line, you are pulled down into the seat by gravity. This is equal to 0 "Gs."

4. During negative "G" forces your weight increases.

5. "G" forces can be either negative or positive.

CORRECT RESPONSES TO FRAME 1: 1. T 2. F 3. F 4. F
5. T

Frame 2

Aircraft environmental systems personnel have the responsibility for the maintenance of the anti-G suit system. The system consists of air lines from the air source to the anti-G suit valve. This valve is shown in figure 2. The air lines then go from the valve to the anti-G suit. The air lines are not normally a source of trouble. Your main job will be checking the anti-G suit valve for proper operation. There are four tests which you will perform: (1) first-stage relief valve adjustment; (2) first-stage chamber pressure adjustment; (3) second-stage relief valve adjustment; (4) trip acceleration test. In order to understand the "Hows and Whys" of the tests, you must know how the valve works.

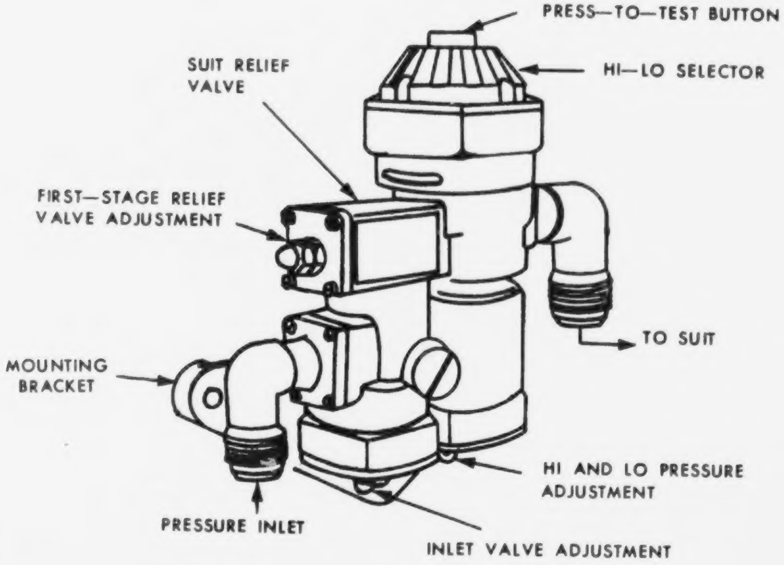

PRESS—TO—TEST BUTTON
SUIT RELIEF VALVE
HI—LO SELECTOR
FIRST—STAGE RELIEF VALVE ADJUSTMENT
TO SUIT
MOUNTING BRACKET
HI AND LO PRESSURE ADJUSTMENT
PRESSURE INLET
INLET VALVE ADJUSTMENT

Figure 2. MD-1 Anti-G Suit Valve.

Answer the statements as true (T) or false (F).

1. Aircraft environmental systems personnel are responsible for checking and testing the anti-G suit valve.

2. There are only three tests you will perform when testing the anti-G suit valve.

3. Air lines are usually the main source of trouble.

4. Before you test the anti-G suit valve, you should know how it works.

During a positive G force, the flow of blood going to the brain is greatly reduced. Low blood pressure causes dizziness, poor eyesight, and a person may soon become unconscious. G forces will affect pilots in different ways, due to the individual's own body structure. The anti-G suit, figure 3, is made of 5 rubber bladders. When the suit is blown up, these bladders tighten around the lower parts of the body. By tightening, enough blood is kept in the brain during a positive G force. The bladders tighten only during positive G forces caused by the aircraft maneuvers. The suit air pressure increases as the positive G forces increase.

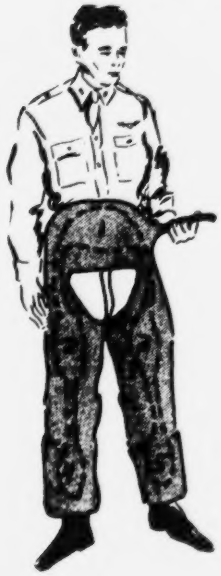


Figure 3. Bladder System.

Answer the statements as true (T) or false (F).

1. No effects are felt by a pilot during a positive G force.

2. During a positive G force maneuver, the blood flow to the brain increases.

3. Decreasing the blood flow to the brain causes dizziness, poor eyesight, and a pilot may soon become unconscious.

4. The anti-G suit is made of four inflatable rubber bladders.

5. The bladders tighten around the lower parts of the body.

6. The pressure decreases in the bladders as the positive G force increases.

CORRECT RESPONSES TO FRAME 2: 1. T 2. F 3. F 4. T

CORRECT RESPONSES TO FRAME 3: 1. F 2. F 3. T 4. F 5. T 6. T

Frame 4

Now let us see how the anti-G suit valve inflates the anti-G suit. Engine bleed air is the source of air used to operate the anti-G suit valve and suit. Look at figure 4 at the back of the text. Follow the arrows as the valve is discussed. As you can see the valve parts are identified. We will discuss the first-stage chamber of the valve. The first-stage chamber has the following parts: air inlet valve (5), first-stage relief valve (6), inlet screen (7), pressure reducing bellows (8), and the adjustment screw (9).

> Note: Both figures show the HI-LO selector in the LO position. When in the LO position, the HI weight is locked in the up position as shown so only the LO weight will move.

Answer the statements as true (T) or false (F).

1. The major parts in the first chamber of the anti-G suit valve are: the pressure reducing bellows and air inlet valve, first-stage relief valve, inlet screen, and the adjustment screw.
2. Engine bleed air is used as a source of air for the anti-G suit.

Bleed air flows into the first-stage chamber through the inlet port. Air pressure in the chamber is controlled at 21 to 22 psi by the air inlet valve (5) and the pressure reducing bellows (8). When chamber pressure is less than 21 to 22 psi, the bellows moves the pivot. This moves the air inlet valve back so bleed air can enter the first-stage chamber. When air pressure in the chamber is 21 to 22 psi the bellows is compressed, and will close the air inlet valve. The adjustment screw (9) is turned right or left to increase or decrease pressure on the spring and put the bellows at the right psi setting. The inlet screen (7) keeps foreign matter out of the anti-G suit valve.

Answer the statements as true (T) or false (F).

1. The pressure reducing valve and the demand valve are both in the first-stage chamber.
2. The purpose of the pressure reducing bellows is to control air pressure in the first-stage chamber.
3. Air pressure in the first-stage chamber is held at 21 to 22 psi.
4. When the bellows expands, the air inlet valve closes.

CORRECT RESPONSES TO FRAME 4: 1. T 2. T

CORRECT RESPONSES TO FRAME 5: 1. F 2. T 3. T 4. F

Frame 6

The first-stage relief valve (6) is located in the first-stage chamber. This serves as a safety valve should the pressure reducing bellows fail to regulate the air pressure at 21 to 22 psi. The relief valve opens when air pressure in the chamber reaches 25 to 26 psi.

Answer the statements as true (T) or false (F).

1. The first-stage chamber air pressure is 21 to 22 psi.
2. The first-stage relief valve acts as a safety valve.
3. The first-stage relief valve is set to open at 25 to 26 psi.

The second-stage chamber controls air pressure to the anti-G suit during a positive "G" force. The second-stage chamber has these parts: press-to-test button (1), HI-LO selector (2), second-stage relief valve (3), second-stage relief valve adjustment screw (4), demand valve (13), diaphram return spring (14), diaphragm (15), deflation valve (16), low weight (17), and high weight (18). Look at figure 4. The demand valve (13) opens and air flows from the first-stage chamber to the second-stage chamber and the anti-G suit. If pressure in the chamber is 9 to 11 psi the second-stage relief valve (3) opens to drop the pressure. Air goes through the vent in the second-stage relief valve. The relief valve is used to stop the buildup of too much pressure in the anti-G suit. It acts as a safety valve. We want just enough pressure in the suit to keep blood from being forced to the feet of the pilot. Too much pressure is as dangerous as not enough. If the suit was over inflated, it would cut off the flow of blood from the pilot's waist down to his feet. The adjustment screw (4) increases or decreases pressure on the spring to put the valve at the proper setting.

Answer the statements as true (T) or false (F).

1. The low and high weights are two parts that are located in the second-stage chamber.
2. Excessive air in the suit would have no effect on the pilot.
3. The demand valve allows air to escape into the first-stage chamber.
4. The second-stage relief valve will relieve pressure at 11 psi.
5. The setting that the second-stage relief valve relieves at depends upon the spring pressure.

CORRECT RESPONSES TO FRAME 6: 1. T 2. T 3. T

CORRECT RESPONSES TO FRAME 7: 1. T 2. F 3. F
4. T 5. T

Frame 8

Look at figure 4 as we explain the way by which the weights control air pressure to the anti-G suit. First we will explain the operation with the HI-LO selector (2) in the LO position. As positive "G" forces build up the LO weight (17), will be forced down on the diaphragm (15), and close the deflation valve (16). The deflation valve is connected to the demand valve (13), which will open. The amount the demand valve opens is determined by the strength of the "G" force acting on the LO weight. Opening the demand valve allows air to flow from the first-stage chamber, through the second-stage chamber to the suit. Keep in mind that air pressure in the second-stage chamber and suit is controlled (9 to 11 psi) by the second-stage relief valve.

When the HI-LO selector is moved to the HI position, the HI weight (18) drops on top of the LO weight. Except for the increase in weight the valve operates as discussed in the LO position.

Look at figure 5. As the "G" force decreases, the weights move up. The diaphragm return spring (14) will force the deflation valve open and releases air pressure from the suit. The demand valve will close. Pressure from the suit will be vented to the cockpit. (Note the direction of the arrows.)

Answer the statements as true (T) or false (F).

1. When a positive "G" force is applied to the weights, the weights move down.

2. The weight forces the diaphragm down and closes the deflation valve.

3. The deflation valve is connected to the demand valve by a common shaft.

4. When no "G" forces are applied, the demand valve opens.

5. When deflating, the pressure from the suit is vented to the cockpit.

The HI-LO selector (2) is used to select a high or low pressure setting to the suit. The pilot selects the position most comfortable for him. When the selector is in the LO range, the low weight controls air to the suit at one (1) psi for every "G" force over 1.7 "Gs."

If a pilot pulls 5 Gs in the low range, pressure to the suit would be approximately 3.3 psi. To figure this problem: Subtract 1.7 Gs from 5Gs and multiply by 1 psi. (5G-1.7G = 3.3G) 3.3G x 1 psi = 3.3 psi to the suit.

Find the psi rating for the G forces shown.

1. 3 Gs ________________ to the suit.
2. 6 Gs ________________ to the suit.
3. 7 Gs ________________ to the suit.
4. 8 Gs ________________ to the suit.

CORRECT RESPONSES TO FRAME 8: 1. T 2. T 3. T 4. F 5. T

CORRECT RESPONSES TO FRAME 9: 1. 1.3 2. 4.3 3. 5.3 4. 6.3

Frame 10

When the HI-LO selector is in the HI position, both the high and low weight control pressure to the suit. When "G" forces act on the weight, they will control pressure to the suit at 1.5 psi for every "G" force over 1.5 "Gs."

Example: If a pilot pulls 7 Gs in the HI range, pressure to the suit would be approximately 8.25 psi. To figure the problem: Subtract 1.5 G from 7 G, this is 5.5 G; multiply 5.5 G by 1.5 psi, this will give you 8.25 psi.

Solve the following problems in the HI range for the pressure to the suit.

1. 3 G ______________ to the suit.

2. 6 G ______________ to the suit.

3. 2 G ______________ to the suit.

4. 8 G ______________ to the suit.

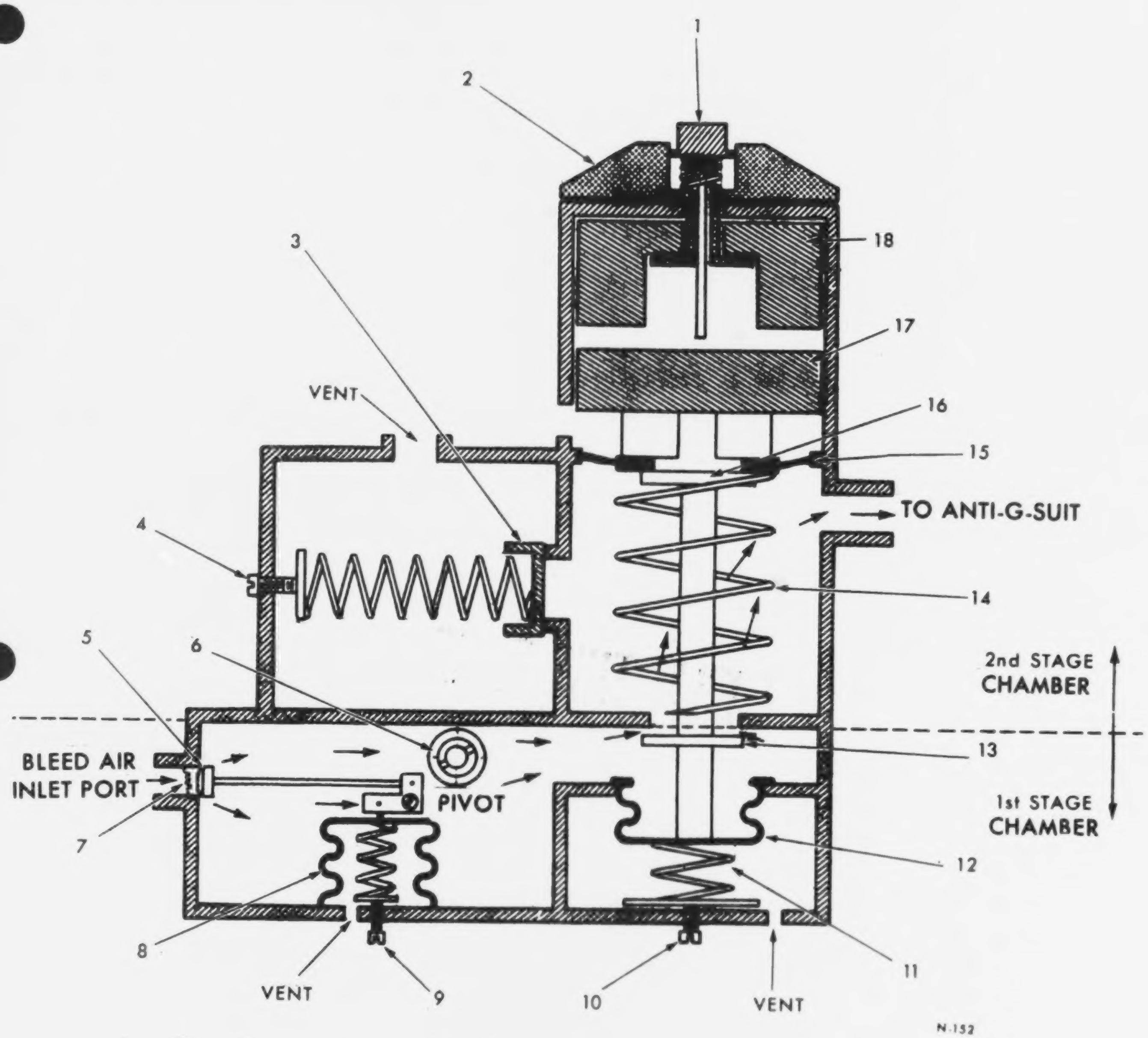
The press-to-test button (1) is used to check for leaks when the pilot makes his hookup between the suit and the valve. It is also used to see if the valve is delivering pressure to his suit. When the press-to-test button is pressed, it forces the low weight down closing the deflation valve and opening the demand valve. It is also used to check the second-stage relief valve.

Answer the statements as true (T) or false (F).

1. The press-to-test button is used to check leaks in the suit.
2. The press-to-test button actuates the low G weight.
3. It is used to check the second-stage relief valve.
4. The pilot does not use the press-to-test button.

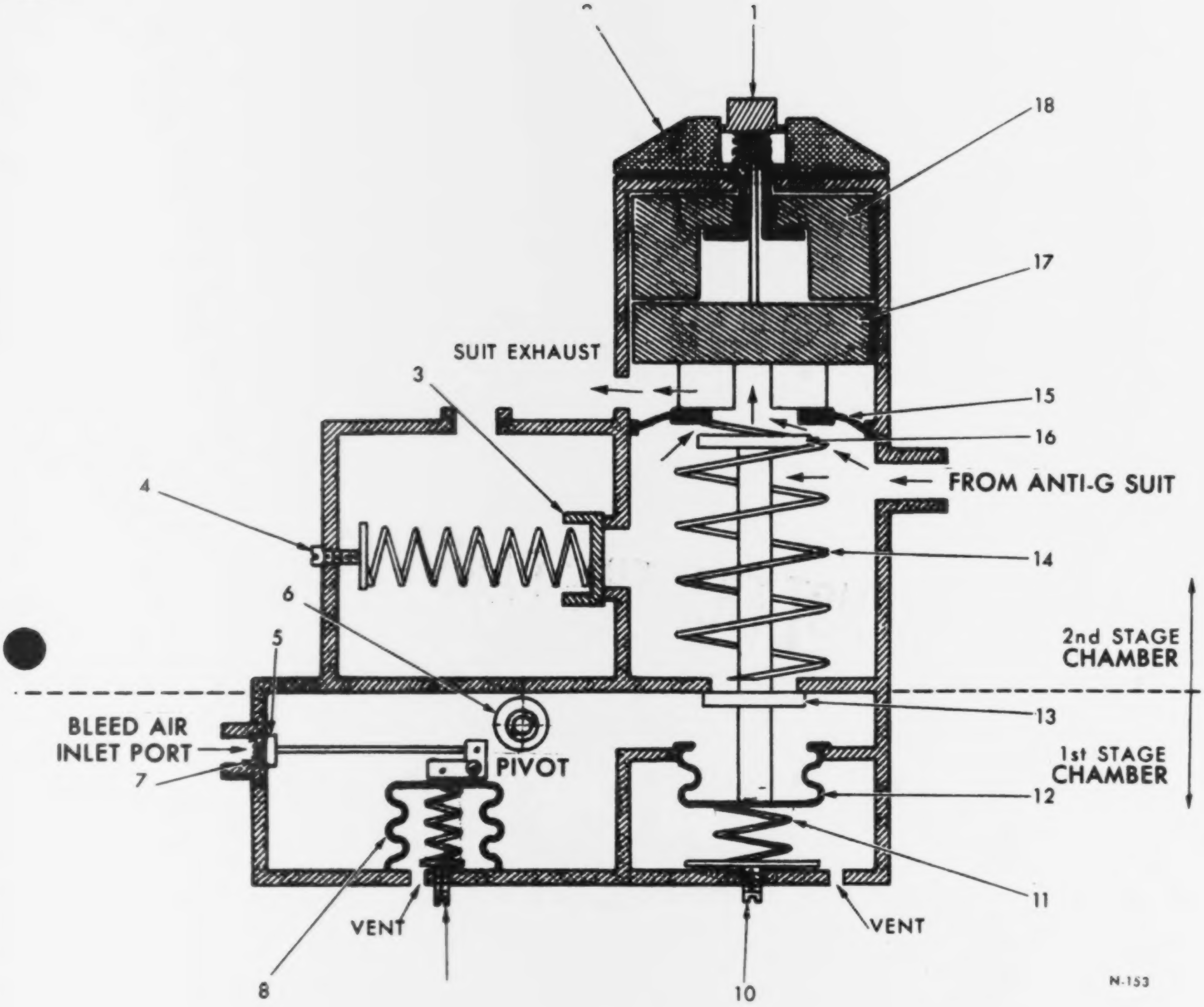
CORRECT RESPONSES TO FRAME 10: 1. 2.25 2. 6.75 3. .75 4. 9.75

CORRECT RESPONSES TO FRAME 11: 1. T 2. T 3. T 4. F


1
2
3
18
17
VENT
16
15
TO ANTI-G-SUIT
4
14
5
6
2nd STAGE CHAMBER
BLEED AIR INLET PORT
PIVOT
13
1st STAGE CHAMBER
7
12
8
11
VENT
9
10
VENT
N-152

1. Press-To-Test Button
2. Hi-Lo Selector
3. Second-Stage Relief Valve
4. Second-Stage Adjustment Screw
5. Air Inlet Valve
6. First-Stage Relief Valve
7. Inlet Screen
8. Pressure Reducing Bellows
9. Pressure Regulator Adjustment
10. Spring Adjustment
11. Valve Return Spring
12. Valve Balancing Bellows
13. Demand Valve
14. Diaphragm Return Spring
15. Diaphragm
16. Deflation Valve
17. Low Weight
18. High Weight

Figure 4. M-8 Anti-G Suit Valve Inflating Suit.


1
18
17
SUIT EXHAUST
3
15
16
FROM ANTI-G SUIT
4
14
6
5
2nd STAGE CHAMBER
BLEED AIR INLET PORT
13
1st STAGE CHAMBER
PIVOT
7
12
11
VENT
VENT
8
10
N-153

1. Press-To-Test Button
2. Hi-Lo Selector
3. Second-Stage Relief Valve
4. Second-Stage Adjustment Screw
5. Air Inlet Valve
6. First-Stage Relief Valve
7. Inlet Screen
8. Pressure Reducing Bellows
9. Pressure Regulator Adjustment
10. Spring Adjustment
11. Valve Return Spring
12. Valve Balancing Bellows
13. Demand Valve
14. Diaphragm Return Spring
15. Diaphragm
16. Deflation Valve
17. Low Weight
18. High Weight

Figure 5. M-8 Anti-G Suit Valve Inflating Suit.

WORKBOOK

C3ABR42331-WB-313

Technical Training

Aircraft Environmental System Mechanic

MAINTENANCE OF ANTI-G SUIT VALVE

10 February 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

RGL: N/A

MAINTENANCE OF ANTI-G SUIT VALVE

OBJECTIVE

Using a ground laboratory test kit, electric-pneumatic component trainer, the necessary handtools, and the applicable TO, inspect and bench check an anti-G suit valve with a maximum of two instructor assists.

Note: An instructor assist is defined as limited aid such as location of a component, technical direction or explanation, and/or technical order interpretation, given to a student who can progress no further alone. Failing to have the instructor check your work at the indicated points and/or failing to follow procedures could result in a performance failure and/or disciplinary action.

EQUIPMENT

Electrical-Pneumatic Trainer (3038)
Anti-G Suit Valve
Ground Laboratory Test Kit
TO 9P5-3-12-3
Pliers, Snap Ring
Screwdriver, Common 5 Inch
Wrench, Adjustable Jaw

PROCEDURE

Caution: If you have any questions about the equipment, ask your instructor for directions. REMOVE ALL YOUR JEWELRY NOW.

INTRODUCTION

1. Obtain an anti-G suit valve, part number (P/N) 10050 from locker number 2.

2. Sign out snap-ring pliers and a screwdriver from locker number 2, and the wrenches from locker number 3.

3. Obtain a ground laboratory test kit from locker number 1.

4. Obtain TO 9P5-3-12-3, Anti-G Suit Valve (Overhaul), from the limited TO file located at the front of the laboratory.

5. Read the Introduction section of TO 9P5-3-12-3, then complete the following statements.

a. Overhaul and test instructions for anti-G suit valve P/N 10050 are given in Sections ______________ and ______________.

b. Additional overhaul and test instructions for anti-G suit valves P/N 12800 and P/N 13500 are given in Section ________________.

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c. All parts removed in the process of disassembly are replaced using parts from a ______________ ______________.

d. Removed parts and residue from the repair kits are

______________ ______________.

6. Read the cleaning and inspection paragraphs of TO 9P5-3-12-3, then complete the following statements.

a. All removed parts are cleaned using a __________ __________ __________ and dry cleaning solvent P/N ___________.

b. All screws and bolts are inspected for ________________.

c. Cleaned parts are dried using ____________ ____________.

d. All washers and spacers are inspected for ______ ______.

e. The component parts of the anti-G suit valve are inspected for ______________ ______________.

f. Table ______________ gives additional inspection requirements.

g. The table lists inspection requirements for the housing as ___________ _________ ___________ and the remedy is ___________ ___________ ____________.

Note: Have the instructor check your answers.

BENCH TEST AND ADJUSTMENT

First Stage Relief Valve

1. Locate the Overhaul Instructions Section of TO 9P5-3-12-3. Read the general paragraph for testing the anti-G suit valve, and the paragraph for testing the first stage relief valve. Complete the following statement.

a. The first stage relief valve is identified in figure __________ as index number __________ of TO #_________________________.

Note: Stop now and see your instructor for instructor initials.

Instructor's Initials __________

2. Locate the first stage relief valve on the anti-G suit valve. Refer to figure 1 of this text and paragraph 1a above. Use the adjustable jaw wrench to remove the valve.

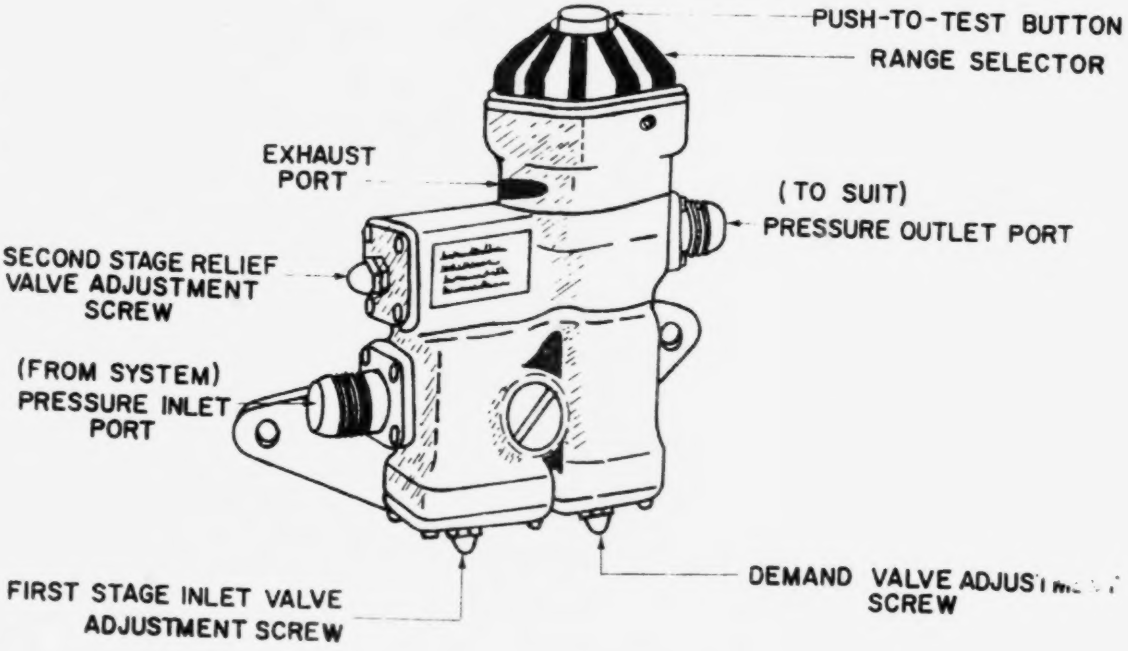
PUSH-TO-TEST BUTTON
RANGE SELECTOR
EXHAUST PORT
(TO SUIT) PRESSURE OUTLET PORT
SECOND STAGE RELIEF VALVE ADJUSTMENT SCREW
(FROM SYSTEM) PRESSURE INLET PORT
DEMAND VALVE ADJUSTMENT SCREW
FIRST STAGE INLET VALVE ADJUSTMENT SCREW

Figure 1. Anti-G Suit Valve (Part Number 10050).

3. Inspect the valve as required by TO 9P5-3-12-3. The valve is satisfactory ________ (yes/no). If unsatisfactory inform the instructor

4. Remove the test adapter from the ground laboratory test kit. The test adapter consists of an elbow and hose adapter. Refer to figure 2 of this workbook. Install the hose adapter and first stage relief valve in the test adapter elbow.

5. Refer to figure 3 of this workbook. Connect the test adapter to the trainer as illustrated. Use the air hoses located on the bottom of the trainer to make the connections.

Note: Check each of the following steps as you complete it.

a._____ Close valve V3 (clockwise) and regulator R3 (counterclockwise).

b._____ Connect a hose between the test adapter and D6 of the trainer.

c._____ Connect a hose between D7 and D4 of the trainer.

d._____ Locate manometer M4; set it to read on the psi scale that is calibrated to read from zero.

Note: Have the instructor check your statements and hook-up before you continue.

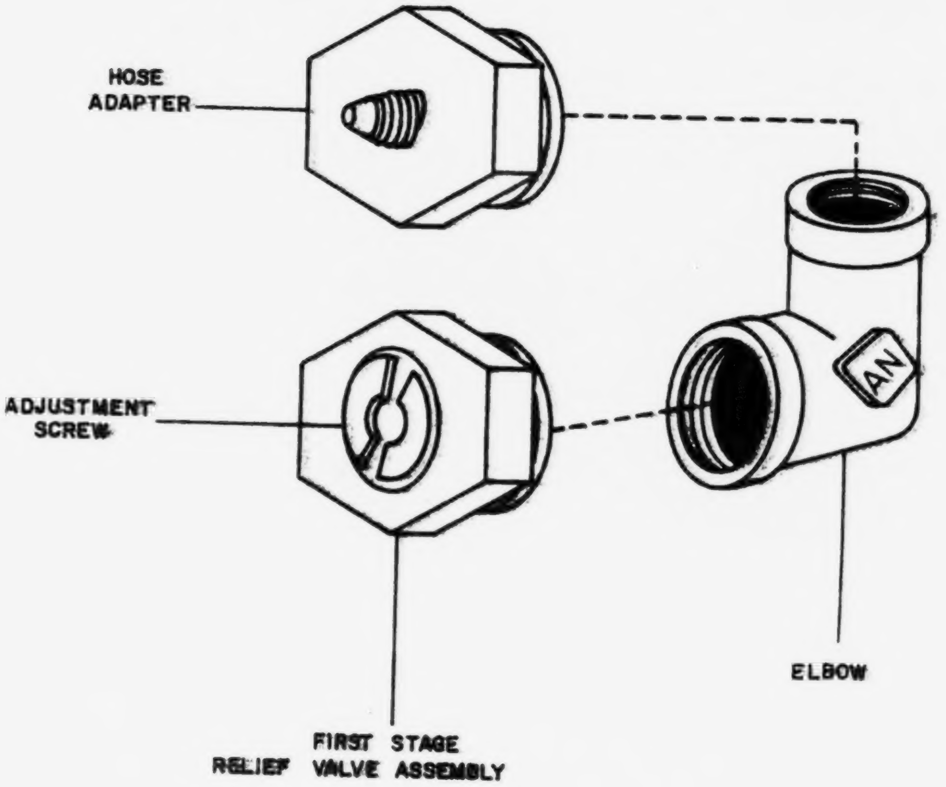
HOSE ADAPTER
ADJUSTMENT SCREW
AN
ELBOW
FIRST STAGE RELIEF VALVE ASSEMBLY

Figure 2. First Stage Relief Valve and Test Adapter.

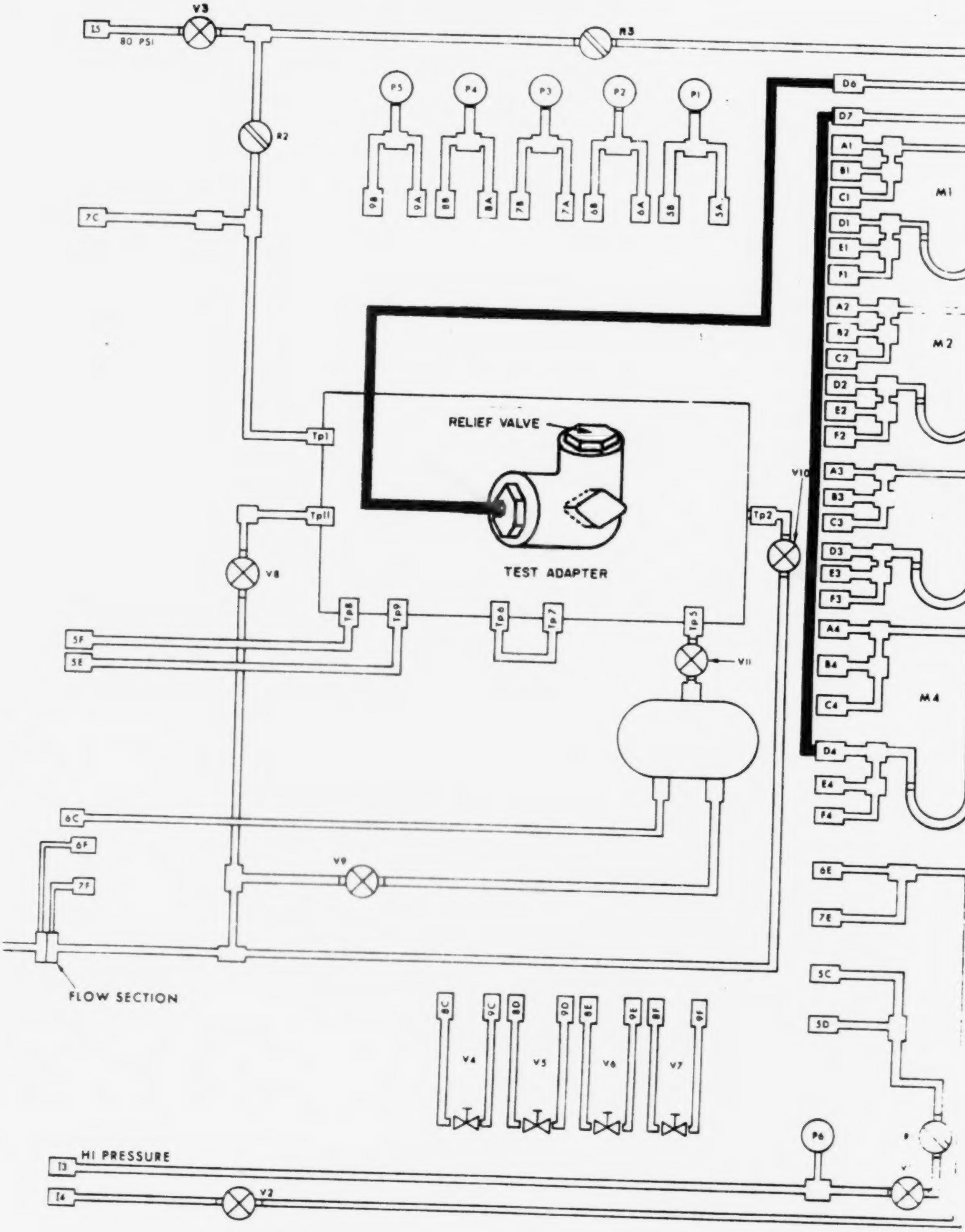
I5
80 PSI
V3
R3
R2
7C
P5
P4
P3
P2
P1
9B
9A
8B
8A
7B
7A
6B
6A
5B
5A
D6
D7
A1
B1
C1
D1
E1
F1
M1
A2
B2
C2
D2
E2
F2
M2
A3
B3
C3
D3
E3
F3
A4
B4
C4
M4
D4
E4
F4
RELIEF VALVE
TEST ADAPTER
Tp1
Tp11
Tp2
V10
V8
Tp8
Tp9
Tp6
Tp7
Tp5
V11
5F
5E
6C
6F
7F
V9
FLOW SECTION
6E
7E
5C
5D
8C
9C
8D
9D
8E
9E
8F
9F
V4
V5
V6
V7
HI PRESSURE
I3
I4
V2
P6
V1

Figure 3. First Stage Relief Valve Test Hook-up
Electrical-Pneumatic Trainer (Schematic).

6. Read the paragraph in TO 9P5-3-12-3, that gives instructions on testing the first stage relief valve. Complete the following questions/statement.

a. If the first stage relief valve is open below 24 psi, what action should be taken? ______________________________

b. If the first stage relief valve is closed above 27 psi, what action should be taken? ______________________________

c. The reading on manometer M4 at the point of opening should be between __________ to __________ psi.

7. Open valve V3 to apply air pressure to the trainer.

8. Observe manometer M4 while applying air pressure to the first stage relief valve. DO NOT EXCEED THE MAXIMUM PRESSURE SETTING (27 [illegible] for the first stage relief valve. Slowly turn regulator R3 clockwise until the relief valve opens. You will hear air escaping from the valve.

9. The first stage relief valve opens at ________ psi.

Note: Refer to figure 2 of this workbook. If adjustment is needed, locate the adjustment screw and adjust as needed.

10. After adjustment the first stage relief valve opens at _____ psi, which should be between the TO specification of ________ to ________ psi.

11. Reduce air pressure to the first stage relief valve by slowly turning regulator R3 counterclockwise, until manometer M4 reads 0 psi.

12. After the air pressure has dropped to 0 psi, disconnect the hose from the hose adapter. Leave the hose connected to D6 of the trainer.

13. Disconnect the hose from D7. Leave the hose connected to D4 of the trainer.

14. Remove the hose adapter from the elbow of the test adapter.

15. Set the hose adapter aside for future use.

16. Remove the first stage relief valve from the elbow of the test adapter. Return the elbow to the ground laboratory test kit.

17. Arrange the parts on the workbench in an orderly manner. You should have: a hose adapter, a first stage relief valve, an anti-G suit valve, a ground laboratory test kit, and hand tools. The trainer should have: a hose connected to D4 and a hose connected to D6.

Note: This test is made to insure that the first stage inlet valve pressure reducer is maintaining the correct inlet pressure to the first stage of the anti-G suit valve.

1. Install the hose adapter in the first stage relief valve port.

2. Remove the cap from the anti-G suit valve inlet port.

3. Refer to figure 4 of this workbook as you connect the anti-G suit valve to the trainer.

Note: Check each step as you complete it.

a._____ Connect the anti-G suit valve, first stage relief valve port to D4 hose.

b._____ Connect the hose installed on D6 to 7A.

c._____ Connect a hose between 7B of the trainer and the anti-G suit valve, inlet port.

Note: Have the instructor check your hook-up before you continue.

4. Apply air pressure to the first stage inlet valve assembly by slowly turning regulator R3 clockwise.

Note: As air pressure is supplied to the first stage inlet valve assembly, gage P3 and manometer M4 indicators should rise together, until both indicate an air pressure of 21 to 22 psi. As air pressure is increased, gage P3 will continue to rise. Manometer M4 should remain at 21 to 22 psi. This is the specified pressure setting for the first stage inlet valve assembly.

5. Slowly increase air pressure until gage P3 indicates 30 to 35 psi. If manometer does not remain at the specified air pressure, notify your instructor. Do not make any adjustments at this time. Read the adjustment procedures in TO 9P5-3-12-3. Figure 2-1, index 19 of the TO locates the adjustment screw on the anti-G suit valve. Figure 1 of this workbook also locates the adjustment screw. Refer to figure 2-1 of the TO. Nut (index 14) must be removed. Loosen lock nut (index 15) before turning the adjustment screw. Turn the screw clockwise or counterclockwise until the desired pressure is indicated on manometer M4. After the adjustment is made, the adjustment screw must be held in place before tightening the lock nut. After the lock nut has been tightened, install and secure nut (index 14).

6. Reduce air pressure by slowly turning regulator R3 counterclockwise.

7. After air pressure has dropped to 0 psi, disconnect the hose from the hose adapter. Leave the hose connected to D4.

8. Do not remove the hose connecting 7A and D6.

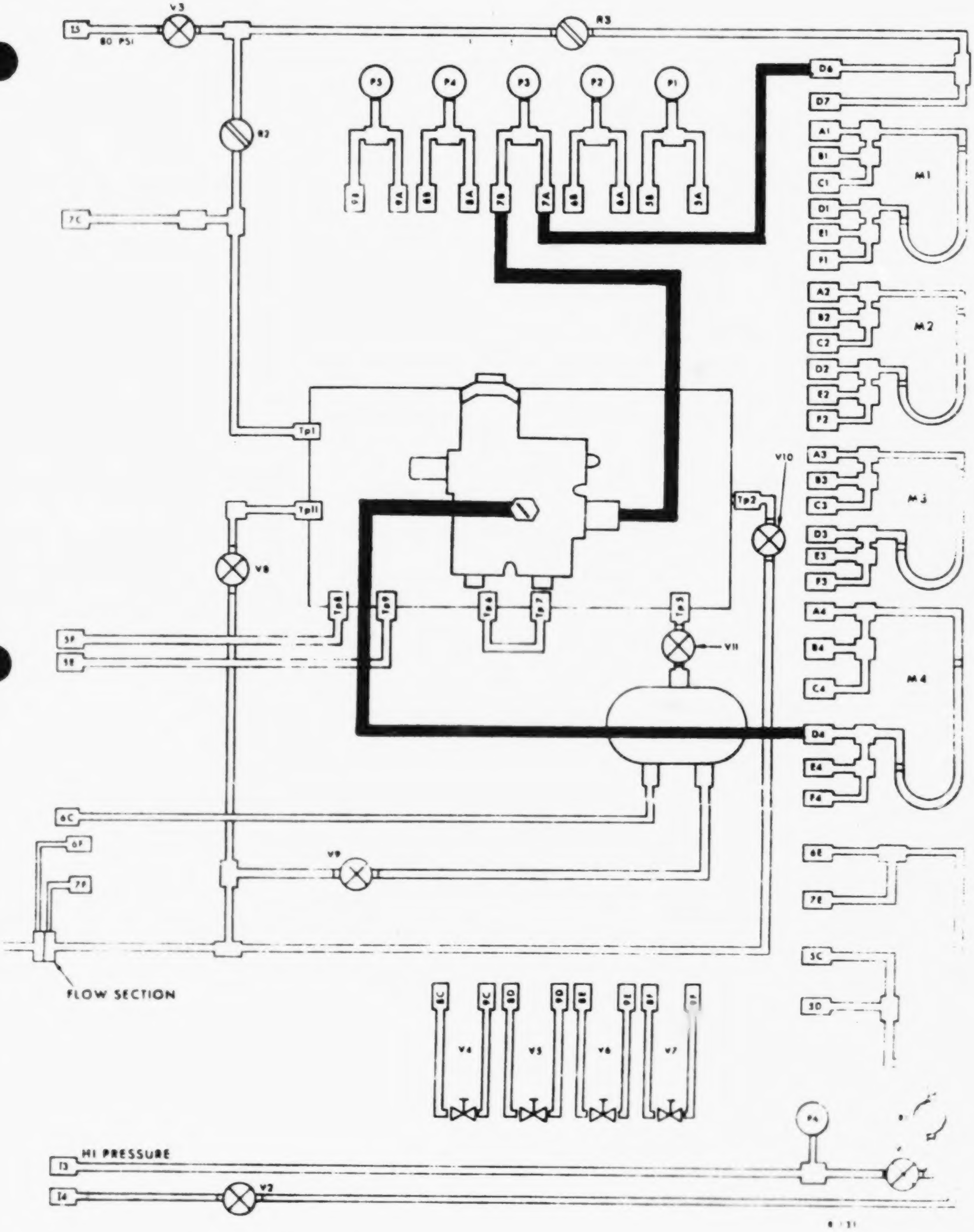
I5
80 PSI
V3
R3
R2
7C
P5
P4
P3
P2
P1
9B
9A
8B
8A
7B
7A
6B
6A
5B
5A
D6
D7
A1
B1
C1
D1
E1
F1
M1
A2
B2
C2
D2
E2
F2
M2
A3
B3
C3
D3
E3
F3
M3
A4
B4
C4
D4
E4
F4
M4
Tp1
Tp11
V8
Tp2
V10
Tp8
Tp9
Tp6
Tp7
Tp3
V11
5F
5E
6C
6F
7F
V9
FLOW SECTION
6E
7E
5C
5D
8C
9C
8D
9D
8E
9E
8F
9F
V4
V5
V6
V7
P6
HI PRESSURE
I3
I4
V2

Figure 4. First Stage Inlet Valve Assembly Test Hook-up Electrical-Pneumatic Trainer (Schematic).

9. Remove the hose adapter from the first stage relief valve port.

10. Install the first stage relief valve in the anti-G suit valve and tighten securely.

11. Return the hose adapter to the ground laboratory test kit.

12. Arrange the parts on the workbench in an orderly manner. You should have: a ground laboratory test kit, a cap, and hand tools. The trainer should have: a hose connected to D4, a hose connected between 7B and the anti-G suit valve inlet port, and a hose connected between 7A and D6.

Second Stage Relief Valve

Note: This test is made to insure air pressure in the second stage does not exceed the specified air pressure.

1. Read the paragraph in TO 9P5-3-12-3, that gives instructions on testing the second stage relief valve. Complete the following statements.

a. The outlet gage (manometer M4) indicates the maximum pressure setting of the valve as _____ psi.

b. Manometer M4 indicates the minimum pressure setting of the valve as _____ psi.

2. Refer to figure 5 of this text as you connect the anti-G suit valve to the trainer.

Note: Check each step as you complete it.

a._____ Remove the cap from the anti-G suit valve outlet port.

b._____ Connect the D4 hose to the anti-G suit valve outlet port.

Note: Have the instructor check your hook-up before you continue.

3. Slowly turn regulator R3 clockwise until gage P3 indicates 20 psi.

4. Depress the anti-G suit valve, push-to-test button and hold it down.

5. Observe the pressure indication on manometer M4 as air escapes from the second stage relief valve.

6. Manometer M4 indicates _____ psi, when the second stage relief valve opened.

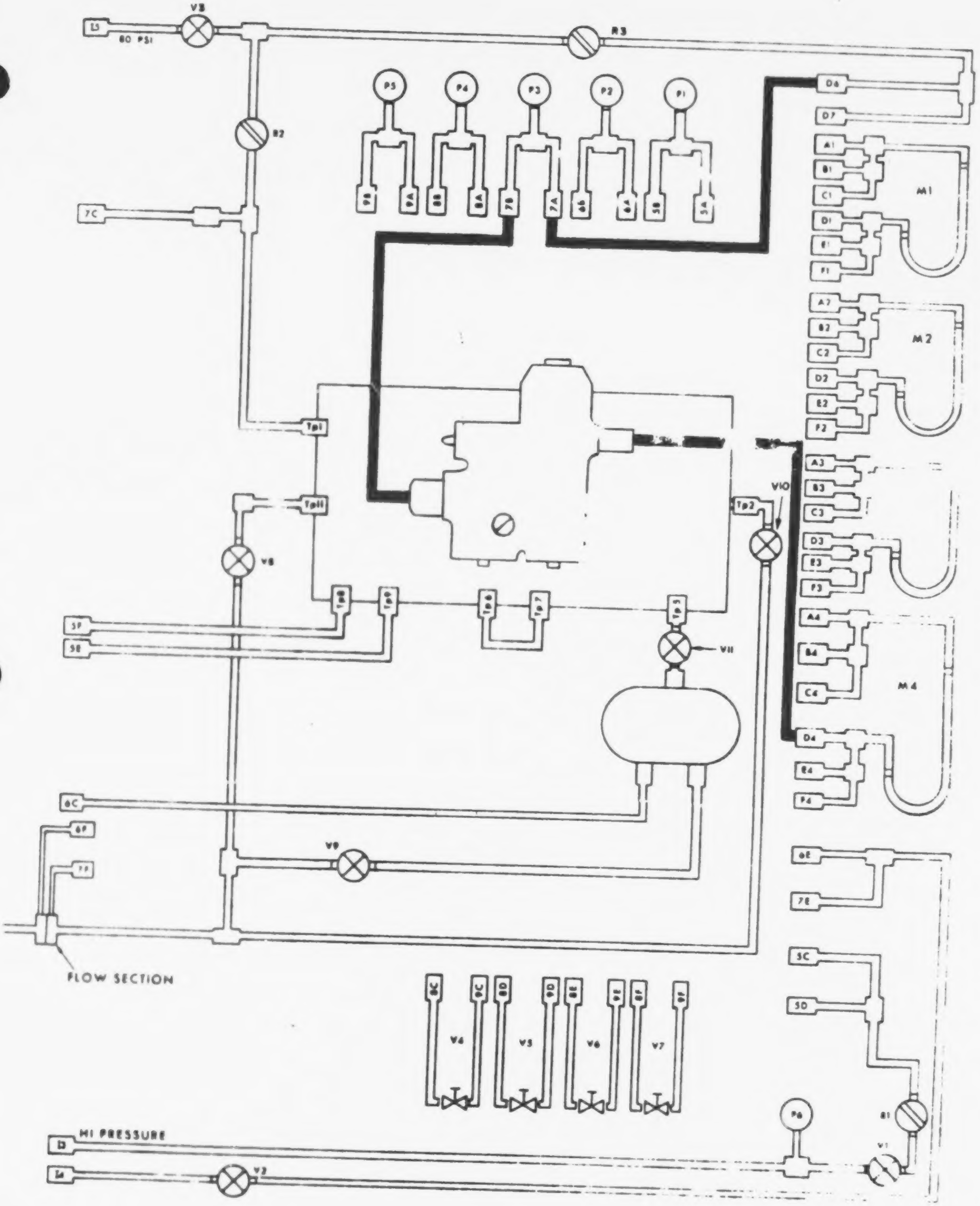
L5
80 PSI
V3
R3
R2
P5
P4
P3
P2
P1
9B
9A
8B
8A
7B
7A
6B
6A
5B
5A
D6
D7
A1
B1
C1
D1
E1
F1
M1
A2
B2
C2
D2
E2
F2
M2
7C
Tp1
Tp11
A3
B3
C3
D3
E3
F3
V10
Tp2
V8
Tp8
Tp9
Tp6
Tp7
Tp3
5F
5E
V11
A4
B4
C4
M4
D4
E4
F4
6C
6F
7F
V9
6E
7E
FLOW SECTION
5C
5D
8C
9C
8D
9D
8E
9E
8F
9F
V4
V5
V6
V7
P6
R1
HI PRESSURE
L3
L4
V2
V1

Figure 5. Second Stage Relief Valve Test Hook-up Electrical-Pneumatic Trainer (Schematic).

7. If the pressure setting is not within the maximum and minimum range, notify your instructor. Do not make any adjustments at this time. Read the adjustment procedures in TO 9P5-3-12-3. Figure 2-2, index 6 of the TO locates the adjustment screw on the anti-G suit valve. Figure 1 of this workbook also locates the adjustment screw. Refer to figure 2-2 of the TO. Nut (index 1) must be removed. Loosen lock nut (index 2) before turning the adjustment screw. Turn the screw clockwise or counterclockwise until the desired pressure is indicated on manometer M4. After the adjustment is made, the adjustment screw must be held in place before tightening the lock nut. After the lock nut has been tightened, install and secure nut (index 1).

8. Reduce air pressure to the valve by slowly turning regulator R3 counterclockwise.

9. After air pressure has dropped to 0 psi, disconnect the hose from the anti-G suit valve, inlet port. Leave the hose connected to 7B.

10. Do not remove the hose connecting 7A and D6.

11. Disconnect the hose from the anti-G suit valve, outlet port and D4.

12. Arrange the parts on the workbench in an orderly manner. You should have: a hose, a ground laboratory test kit, two (2) caps, and hand tools. The trainer should have: an anti-G suit valve, a hose connected between 7A and D6, and a hose connected to 7B.

Demand Valve

Preparation Step

1. Remove the "L" shaped bracket and mounting nuts from the ground laboratory test kit.

2. Hold the anti-G suit valve in your left hand. The push-to-test button must be up and the identification (ID) plate facing you. Insert the "L" shaped bracket from front to rear. Secure the valve to the anti-G suit bracket with the mounting nuts.

3. Mount the anti-G suit valve on the tester.

4. Refer to figure 6 of this workbook. Use the snap-ring pliers to remove the snap-ring that holds the push-to-test button in place. Set the snap-ring aside for reassembly after the test is completed.

5. Remove the push-to-test button and pin assembly.

6. Remove the spring. Set aside for reassembly after the test is completed.

7. Place only the push-to-test button and pin assembly back on the valve.

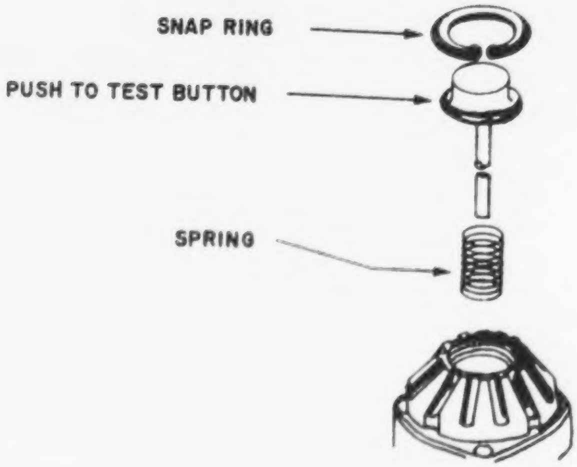

Figure 6. Range Selector.

8. Refer to figure 7 of this workbook as you connect the anti-G suit valve to the trainer.

Note: Check each step as you complete it.

a._____ Connect a hose between the anti-G suit valve outlet and TP5 on the trainer.

b._____ Connect a hose between 6C and F4 on the trainer.

Note: Have the instructor check your hook-up before you continue.

Acceleration Test (LO Position)

1. Set the range selector of the anti-G suit valve to the LO position.

2. Remove the LO weights and LO adapter from the ground laboratory test kit and arrange them on the workbench.

Note: The LO (low) weights are solid and are marked LO. The LO adapter is used to hold the LO weights on the push-to-test button. The adapter has a G unit value of 0.5 G and the weights range in value from 0.25 G to 4.0 Gs.

3. Slowly turn regulator R3 clockwise until gage P3 indicates 40 psi.

4. Slowly open valve V11, this allows air pressure to be directed to manometer M4.

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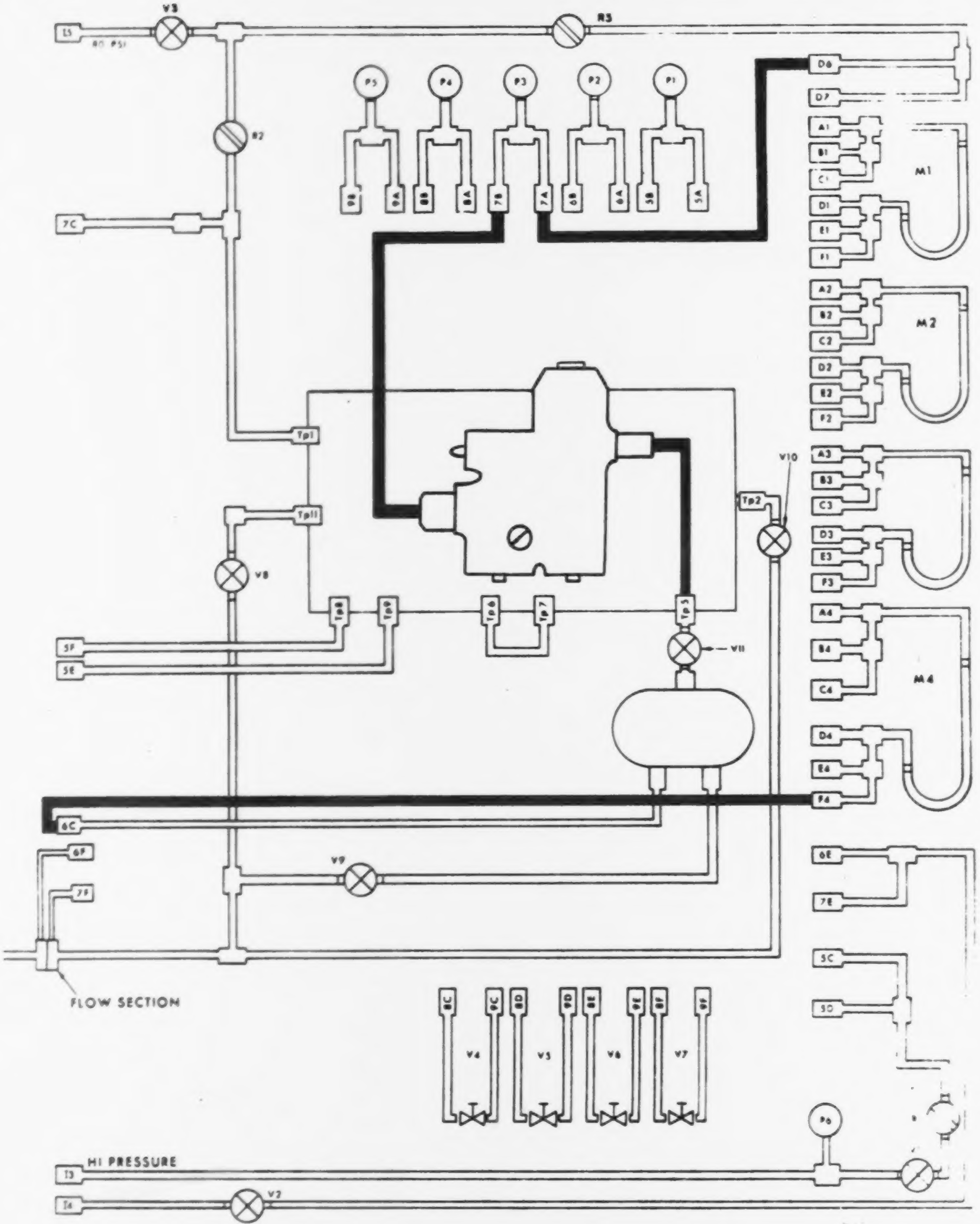

T5
80 PSI
V3
R3
R2
7C
P5
P4
P3
P2
P1
9B
9A
8B
8A
7B
7A
6B
6A
5B
5A
D6
D7
A1
B1
C1
D1
E1
F1
M1
A2
B2
C2
D2
E2
F2
M2
A3
B3
C3
D3
E3
F3
A4
B4
C4
D4
E4
F4
M4
Tp1
Tp11
V8
Tp2
V10
Tp8
Tp9
Tp6
Tp7
Tp5
V11
5F
5E
6C
6F
7F
V9
FLOW SECTION
6E
7E
5C
5D
8C
9C
8D
9D
8E
9E
8F
9F
V4
V5
V6
V7
P6
T3
HI PRESSURE
T4
V2

Figure 7. Demand Valve Test Hook-up Electrical-Pneumatic Trainer (Schematic).

5. Refer to TO 9P5-3-12-3, Table 3-2. The table lists the weights used when simulating a total "G" load test. Use the table to determine the weight needed to perform the following tests.

LO RANGE TESTS

2.0 G ____ psi

8.0 G ____ psi

Note: Table 3-2 in TO 9P5-3-12-3 takes into account the 1 G weight that is inside the anti-G suit valve for both the LO and HI tests.

6. Assemble on the LO adapter the weight needed to perform a LO range test. Place the adapter and weights on the push-to-test button. Observe manometer M4 and record the readings for each test.

Note: Make certain the "G" weights and adapter are resting firmly on the push-to-test button and are not leaning. Rotate the weights and adapter slowly during the test, until the readings are constant. This insures that the weights and adapter are bearing full force on the demand valve.

7. Refer to figure 8 of this text. The LO Range Graph indicates the air pressure required for a given number of "G" units. The pressure indicated by manometer M4 should fall between the two diagonal lines. The vertical lines indicate the value of the weights (G units) placed on the push-to-test button. Read from this line horizontally to the pressure (psi) indicated by manometer M4. If the manometer pressure indication does not fall between the diagonal lines, an adjustment must be made to the demand valve.

8. If manometer M4 does not remain at the specified air pressure, notify the instructor. Do not make any adjustment at this time.

Note: Read the adjustment procedures in TO 9P5-3-12-3. Figure 2-3, index 27 of the TO locates the adjustment screw on the anti-G suit valve. Figure 1 of this workbook also locates the adjustment screw. Refer to figure 2-3 of the TO. Nut (index 22) must be removed. Loosen lock nut (index 23) before turning the adjustment screw. Turn the screw clockwise or counterclockwise until the desired pressure is indicated on manometer M4. After the adjustment is made, the adjustment screw must be held in place before tightening the lock nut. After the lock nut has been tightened, install and secure nut (inde22).

9. Remove the LO weights and adapter from the push-to-test button.

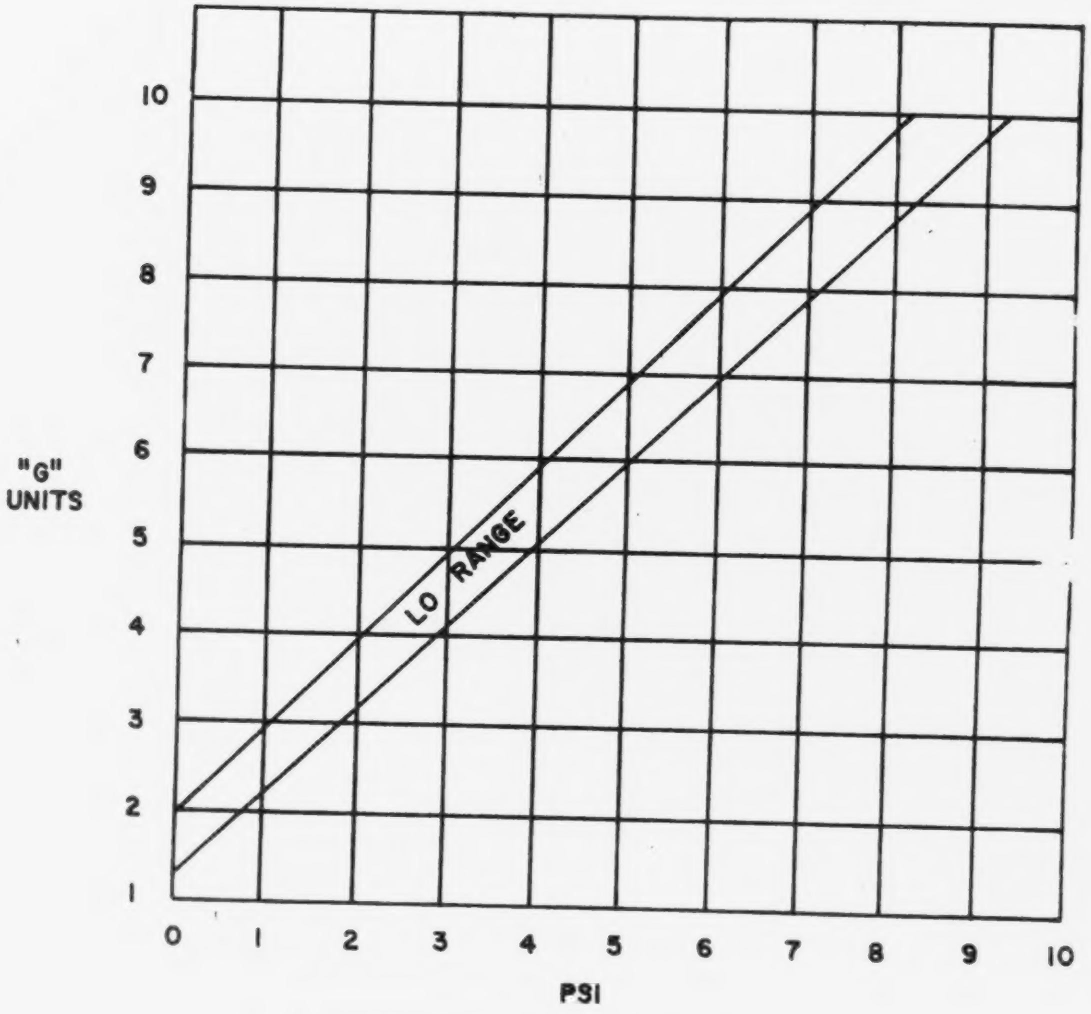


Figure 8. LO Range Graph.

Acceleration Test (HI Position)

1. Set the range selector of the anti-G suit valve to the HI position.

2. Remove the HI weights and HI adapter from the ground laboratory test kit. Arrange the LO and HI weights and adapters on the workbench.

> Note: The HI (high) weights and HI adapter are marked HI. The weights are recessed to receive the LO weights. Both the HI and LO weights are used to perform the HI range tests. The G unit value of the HI weights and adapter is the same as for the LO weights and adapter. The LO adapter is not used for HI range tests; return it to the test kit.

3. Refer to TO 9P5-3-12-3, Table 3-2. The table lists the weights used when simulating a total "G" load test. Use the table to determine the weight needed to perform the following tests.

HI RANGE TESTS

2.0 G _____ psi

6.0 G _____ psi

8.0 G _____ psi

4. Assemble on the HI adapter the LO and HI weights needed to perform a HI range test. Place the adapter and weights on the push-to-test button. Observe manometer M4 and record the readings for each test.

> Note: Make certain the "G" weights and adapter are resting firmly on the push-to-test button and are not leaning. Rotate the weights and adapter _slowly_ during the test, until the readings are constant. This insures that the weights and adapter are bearing full force on the demand valve.

5. Refer to figure 9 of this workbook. The HI Range Graph indicates the air pressure required for a given number of "G" units. The pressure indicated by manometer M4 should fall between the two diagonal lines. The vertical lines indicate the value of the weights (G units) placed on the push-to-test button. Read from this line horizontally to the pressure (psi) indicated by manometer M4. If the manometer pressure indication _does not_ fall between the diagonal lines, an adjustment must be made to the demand valve.

6. If manometer M4 does not remain at the specified air pressure, notify the instructor. _Do not_ make any adjustment at this time.

> Note: Read the adjustment procedures in TO 9P5-3-12-3. Figure 2-3, index 27 of the TO locates the adjustment screw on the anti-G suit valve. Figure 1 of this workbook also locates the adjustment screw. Refer to figure 2-3 of the TO. Nut (index 22) must be removed. Loosen lock nut (index 23) before turning the adjustment screw. Turn the screw clockwise or counterclockwise until the desired pressure is indicated on manometer M4. After the adjustment is made, the adjustment screw must be held in place before tightening the lock nut. After the lock nut has been tightened, install and secure nut (index 22).

7. Remove the LO and HI weights and HI adapter from the push-to-test button.

Shut-Down Steps

1. Reduce air pressure to the anti-G suit valve by _slowly_ turning regulator R3 counterclockwise.

2. Close valve V3 to shutoff pressure to the trainer.

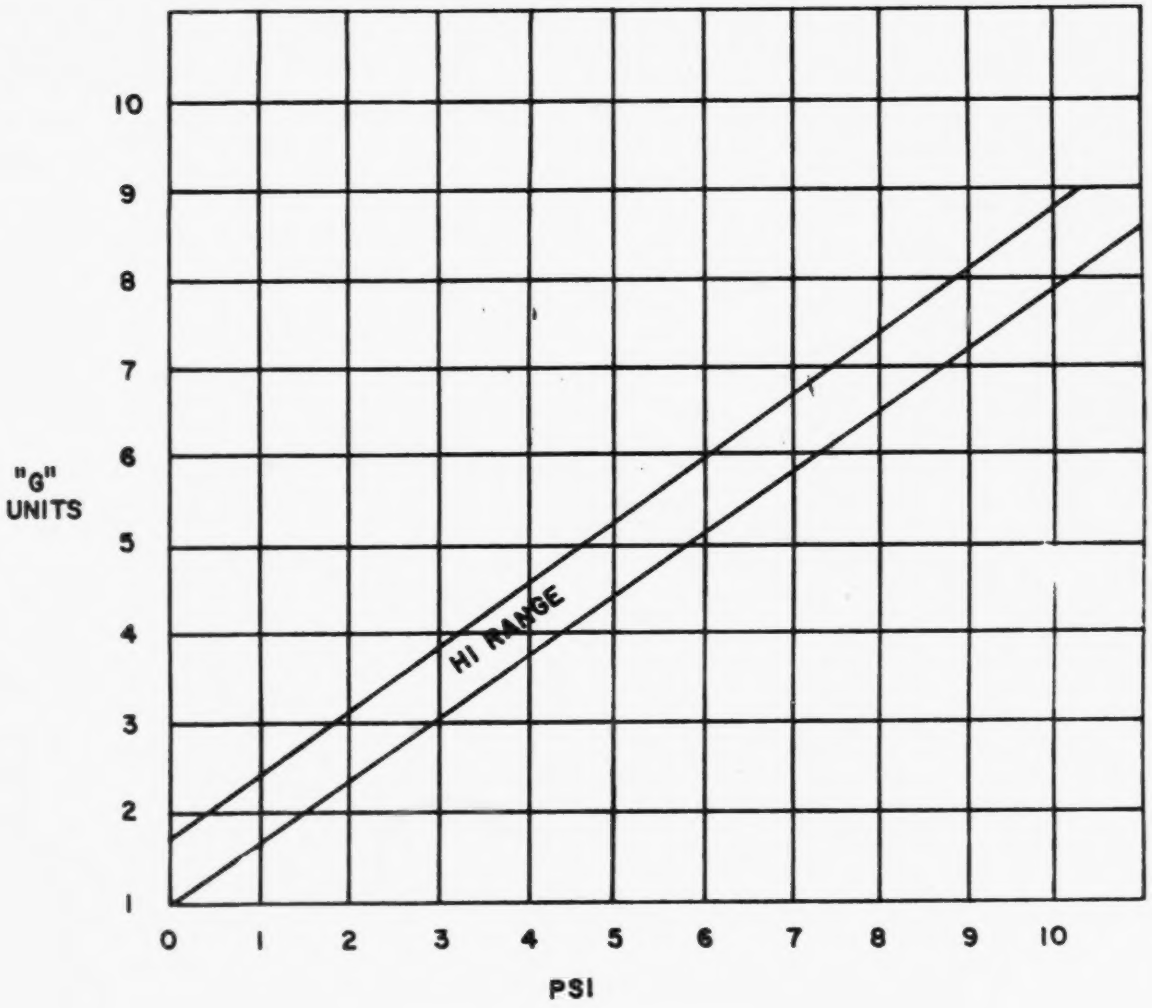


Figure 9. HI Range Graph.

3. Close valve V11 to shutoff pressure to manometer M4.

4. After air pressure has dropped to 0 psi, disconnect the hose between D6 and 7A. Store the hose in the bottom of the trainer.

5. Disconnect the hose between TP5 and the anti-G suit valve outlet port. Plug and store the hose in the bottom of the trainer.

6. Disconnect the hose between 7B and the anti-G suit valve inlet port. Plug and store the hose in the bottom of the trainer.

7. Disconnect the hose between 6C and F4. Plug and store the hose in the bottom of the trainer.

8. Remove the push-to-test button and pin assembly from the anti-G suit valve.

9. Install the spring, push-to-test button and pin assembly, and snap ring back on the valve.

10. Remove the anti-G suit valve from the tester.

11. Remove the "L" shaped bracket from the anti-G suit valve. Return the "L" shaped bracket and mounting nuts to the ground laboratory test kit.

12. Return the LO weights, HI weights, and HI adapter to the ground laboratory test kit. Store the test kit in locker number 1.

13. Cap all openings of the anti-G suit valve. Store the anti-G suit valve, snap-ring pliers, and screwdriver in locker number 2.

14. Store the wrenches in locker number 3.

15. Clean the trainer, workbench and work area.

Note: Check with the instructor for further instructions.

Instructor assists 1. __________ 2. __________

PROGRAMMED TEXT

3ABR42331-PT-314

Technical Training

Aircraft Environmental Systems Mechanic

CANOPY SEAL SYSTEM

3 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: 9.7

OBJECTIVE

Relate the major components of the Canopy Seal System to their operations with 80% accuracy.

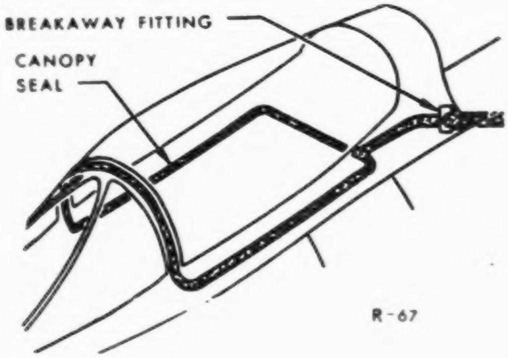
INSTRUCTIONS

This programmed text presents information in small steps called "frames". After each frame, you are expected to respond by supplying a word, or words, to complete the sentence, choose either a true or false statement, select the correct answer, or match some term to their proper meaning.

Read the material presented, select your response(s) as required at the end of the frame. After you have made your selection check your responses on the top of the next page. DO NOT MARK IN THIS TEXT. If your selections were correct, go on to the next frame and repeat the above process. If you made an incorrect response, reread the frame until you understand your error.

Supersedes 3ABR42231-PT-314, 20 August 1975.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; TTVSA - 1

High altitude aircraft use a pressurization system for the comfort and safety of the crew. The canopy seal (inflatable tube) is located between the canopy and the aircraft fuselage, see below. When this seal is inflated it will stop the loss of cockpit pressure when air pressure inside the aircraft is more than the air pressure outside of the aircraft. The seal can be fastened to the aircraft or the canopy and give the same results. A regulator is put in the system to control pressure in the seal. By controlling pressure, the regulator will keep the seal from rupturing.



Answer the statements (T) or false (F).

a. The canopy seal prevents the loss of cockpit pressure.

b. The canopy seal is always fastened to the canopy.

c. Low pressure in the seal will cause it to rupture.

d. The canopy seal prevents a loss of cabin pressure at any altitude.

e. The canopy seal regulator controls pressure in the cockpit.

f. The canopy seal is inflated to make the proper seal.

Answers to Frame 1: a. T , b. F , c. T , d. F ,
e. F , f. T

Frame 2

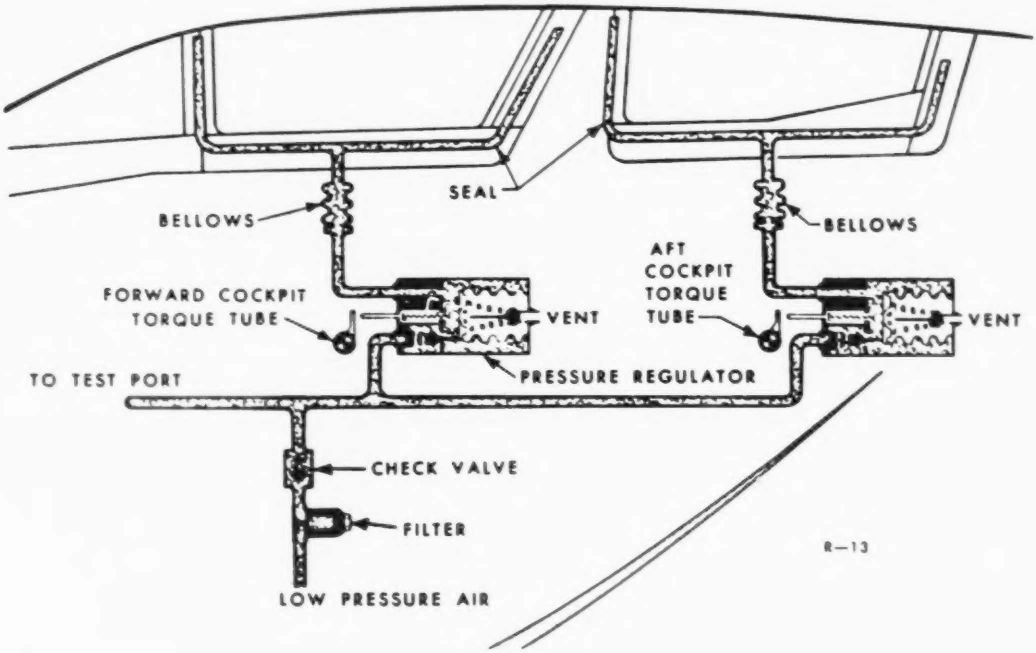
The seal is made of rubber. When regulated air pressure is applied, the seal expands and makes a seal between the canopy and the cockpit.

Identify the statement that tells how the canopy seal makes the canopy airtight.

a. By sea level air pressure in the seal, causing it to expand at altitude.

b. By applying a constant regulated air pressure to the seal, causing it to expand.

c. By blowing the seal up as you would a car tire.


SEAL
BELLOWS
BELLOWS
FORWARD COCKPIT TORQUE TUBE
AFT COCKPIT TORQUE TUBE
VENT
VENT
PRESSURE REGULATOR
TO TEST PORT
CHECK VALVE
FILTER
LOW PRESSURE AIR
R—13

Answer to Frame 2: b

Frame 3

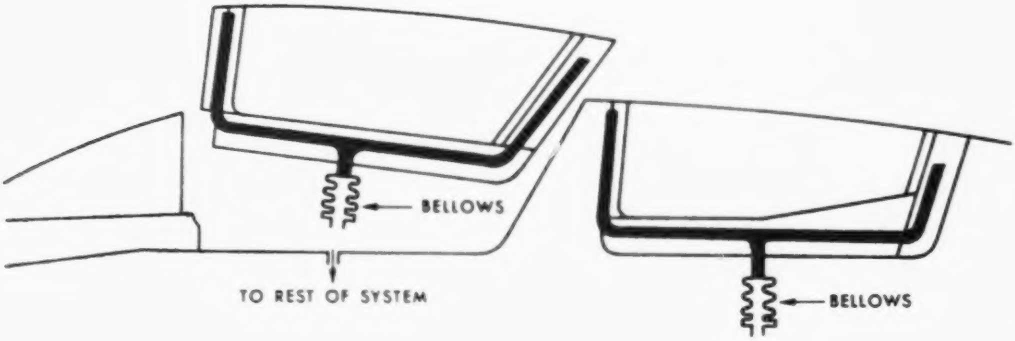
A bellows is a vented type flexible container (such as the flexible part of an accordian) that connects two units. Look at the diagram, the bellows in the canopy seal system is used to

a. vent the canopy seal to the atmosphere.

b. vent the canopy seal to the cockpit.

c. provide a test port connection.

d. connect the canopy seal to the rest of the system when the canopy is closed.



R—14

Answer to Frame 3: d

Frame 4

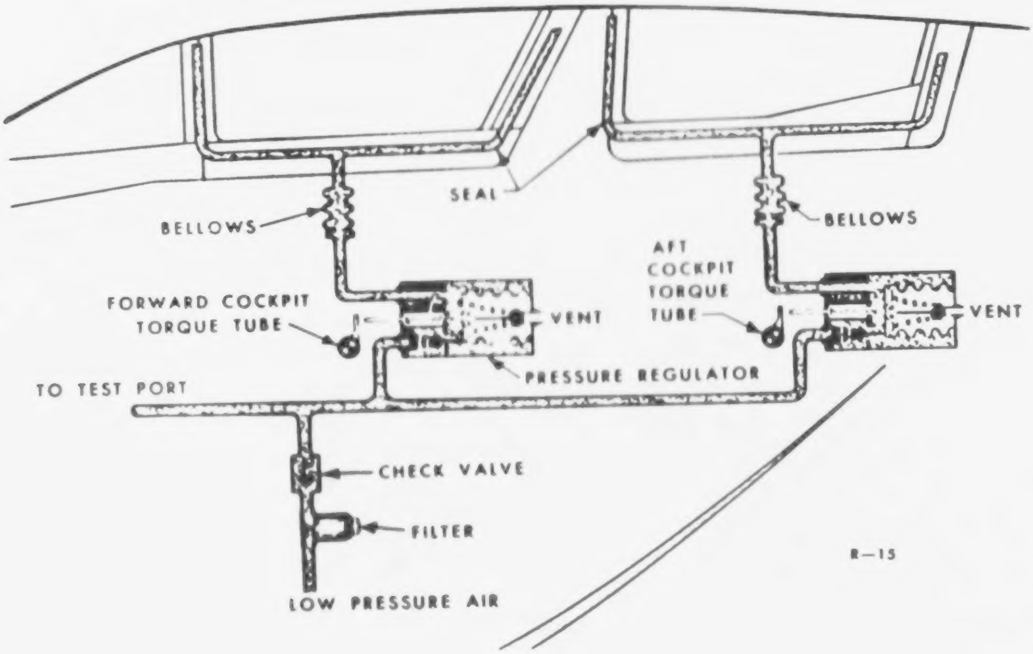
The canopy seal is expanded by air at a low pressure. This low pressure air is from the auxiliary air source and flows through the canopy seal regulator.

The canopy seal air pressure is regulated by the

a. cockpit pressure regulator.

b. air conditioning system pressure regulating and shutoff valve.

c. canopy seal pressure regulator.


SEAL
BELLOWS
BELLOWS
AFT COCKPIT TORQUE TUBE
FORWARD COCKPIT TORQUE TUBE
VENT
VENT
PRESSURE REGULATOR
TO TEST PORT
CHECK VALVE
FILTER
LOW PRESSURE AIR
R—15

Answer to Frame 4: c

Frame 5

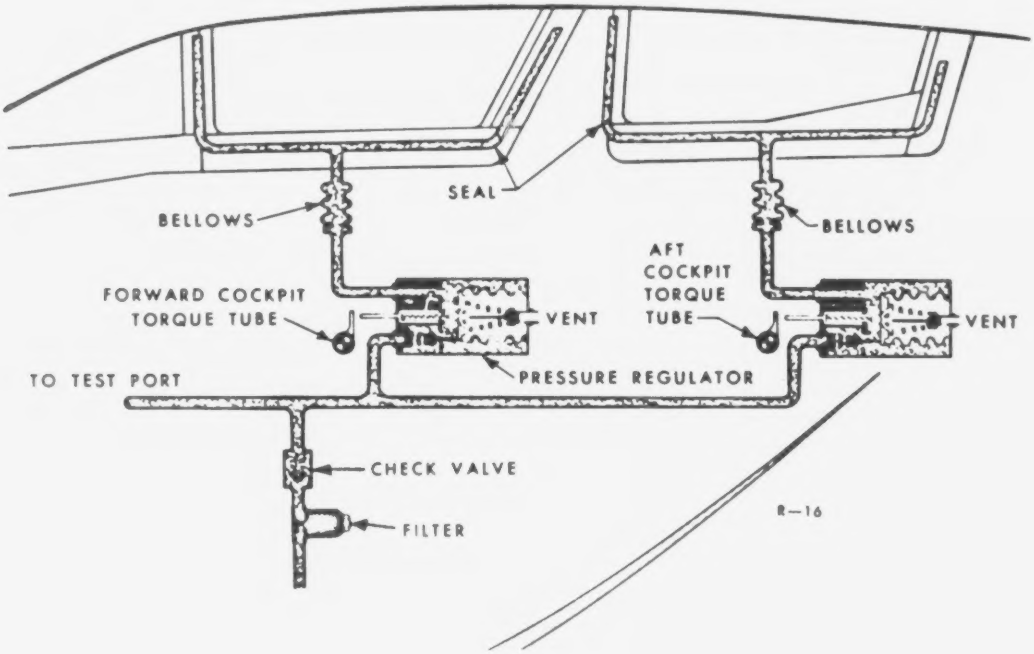
The regulator keeps a 20 to 24 psi of air pressure in the seal during pressurized flight. Operation of the regulator is covered later in the text.

Which of the following states the purpose of the canopy seal pressure regulator?

a. Keeps 20 to 24 psi of air pressure to canopy seal during pressurized flight.

b. Regulates the air pressure leaving the canopy seal at 20 psi.

c. Keeps a 20 to 24 psi differential air pressure between the seal and cockpit pressure.


SEAL
BELLOWS
BELLOWS
AFT COCKPIT TORQUE TUBE
FORWARD COCKPIT TORQUE TUBE
VENT
VENT
TO TEST PORT
PRESSURE REGULATOR
CHECK VALVE
FILTER
R—16

Answer to Frame 5: a

Frame 6

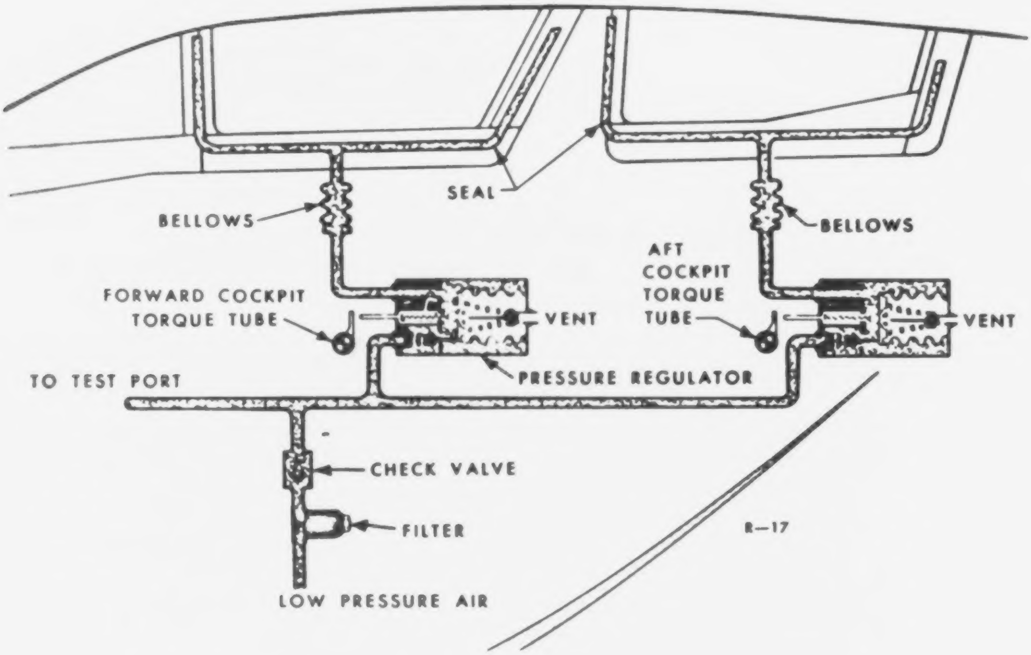
Particles, such as soot, that may be found in the auxiliary air source could be harmful to the canopy seal and the canopy seal components. Look at the diagram. Which of the items is used to take out particles from the air used by the canopy seal system?

a. Canopy Seal Bellows

b. Filter

c. Check Valve

d. Pressure Regulator


SEAL
BELLOWS
BELLOWS
AFT COCKPIT TORQUE TUBE
FORWARD COCKPIT TORQUE TUBE
VENT
VENT
TO TEST PORT
PRESSURE REGULATOR
CHECK VALVE
FILTER
R—17
LOW PRESSURE AIR

Answer to Frame 6: b

Frame 7

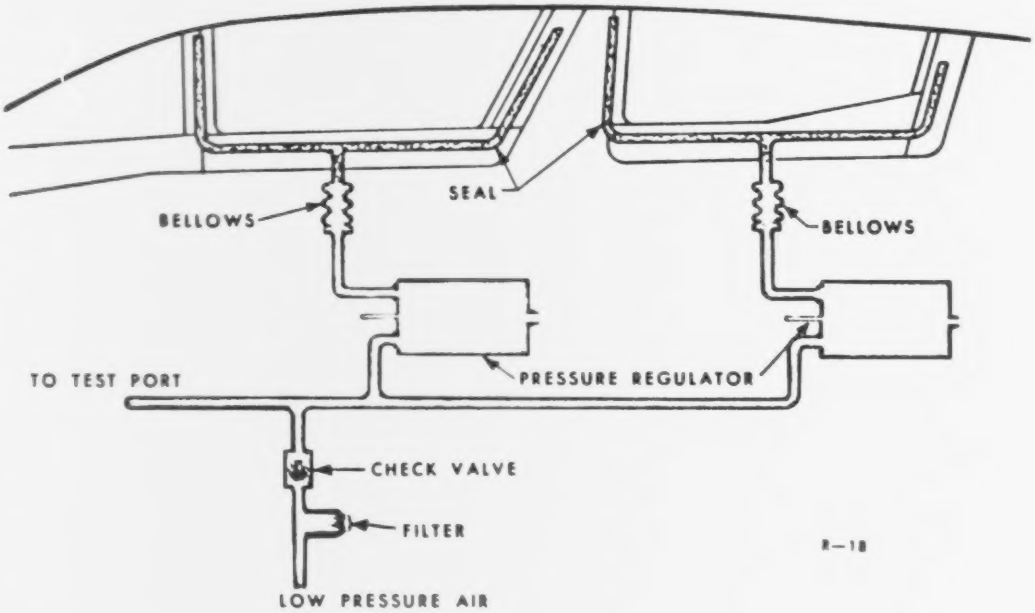
The seal is placed in a channel of the canopy. The rest of the system is in the fuselage. Look at the diagram. Identify the statement that tells how the seal is connected to the system, when the canopy is closed.

a. A quick disconnect fitting.

b. A channel band clamp.

c. Canopy seal bellows.

d. A band clamp.


SEAL
BELLOWS
BELLOWS
PRESSURE REGULATOR
TO TEST PORT
CHECK VALVE
FILTER
LOW PRESSURE AIR
R-18

Answer to Frame 7: c

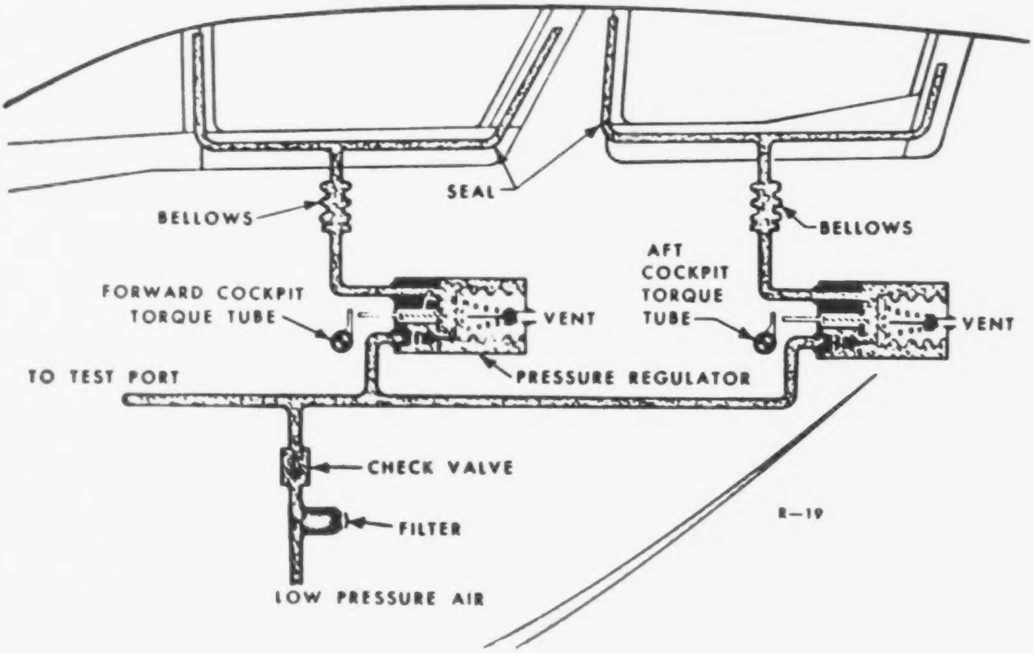
Frame 8

The canopy seal check valve stops the air that flows to the seal from flowing back to the auxiliary air source, when the ground test port is used. Look at the diagram. When will the check valve stop the flow of air to the auxiliary air source?

a. During all pressurized flight.

b. When using the ground test port.

c. When deflating the seal.


SEAL
BELLOWS
BELLOWS
AFT COCKPIT TORQUE TUBE
FORWARD COCKPIT TORQUE TUBE
VENT
VENT
TO TEST PORT
PRESSURE REGULATOR
CHECK VALVE
FILTER
LOW PRESSURE AIR
R—19

Answer to Frame 8: b

Frame 9

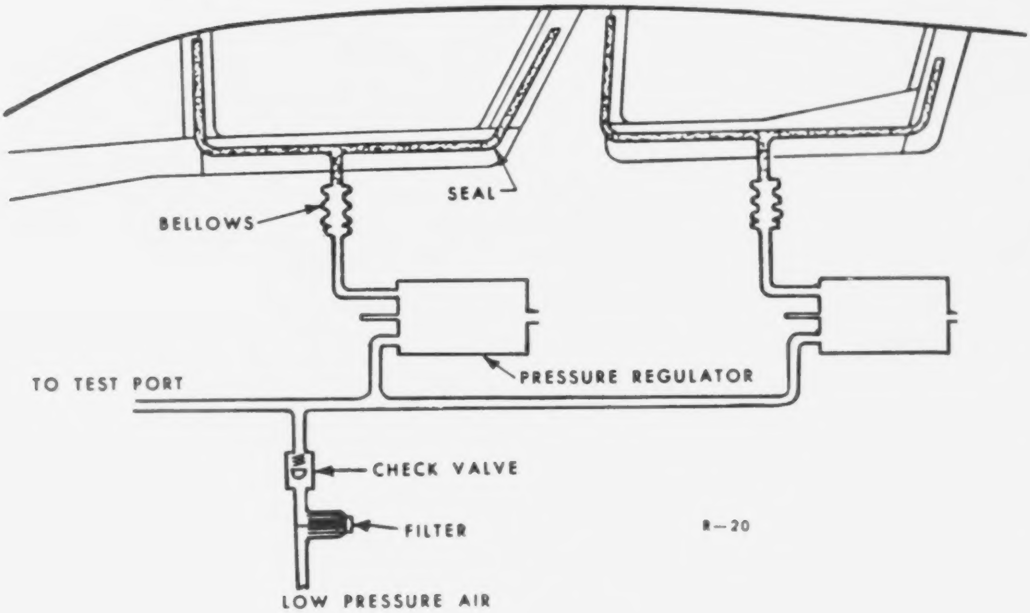
The system has a test port that is used to check for leaks and operation when the aircraft is on the ground. A ground air cart is used as a pressure source when ground checks need to be made. Which statement tells where the ground air cart is connected to the system?

a. At the bellows.

b. At the pressure regulator.

c. At the filter.

d. At the ground test port.

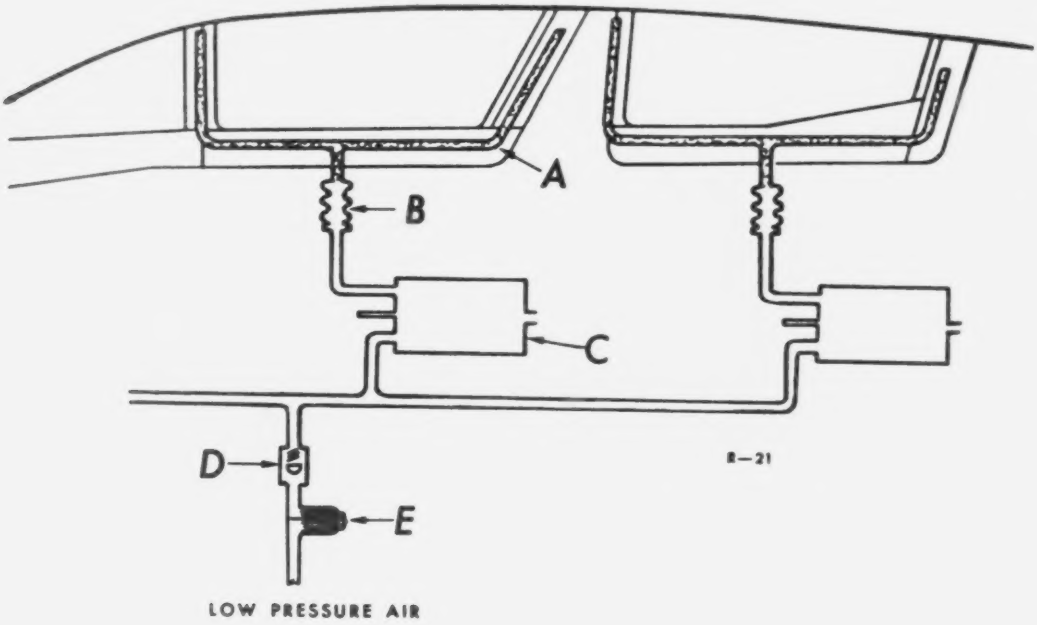

SEAL
BELLOWS
PRESSURE REGULATOR
TO TEST PORT
CHECK VALVE
FILTER
R—20
LOW PRESSURE AIR

Answer to Frame 9: d

Frame 10

Look at the diagram. Match the components with the letter that identifies the component in the diagram.

1. Check Valve
2. Seal
3. Regulator
4. Filter
5. Bellows

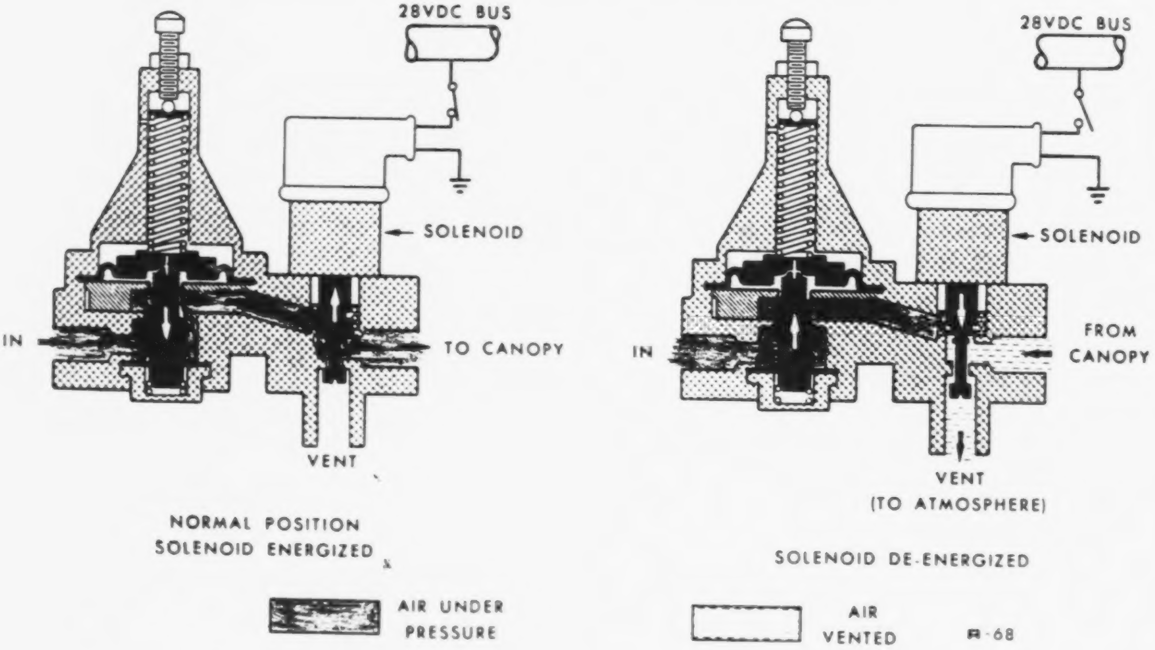

A
B
C
D
E
LOW PRESSURE AIR
R—21

1020

Answers to Frame 10: 1. D , 2. A , 3. C , 4. E ,
5. B

Frame 11

The canopy seal regulator controls the air in the seal to 20 and 24 psi. The regulator has a shutoff and dump valve. High pressure air is tapped off of the engine bleed air duct. A solenoid is used to control the position of the shutoff and dump valve. The solenoid is energized by 28V DC. Study the diagram below.


28VDC BUS
SOLENOID
IN
TO CANOPY
VENT
NORMAL POSITION
SOLENOID ENERGIZED
28VDC BUS
SOLENOID
IN
FROM CANOPY
VENT
(TO ATMOSPHERE)
SOLENOID DE-ENERGIZED
AIR UNDER PRESSURE
AIR VENTED
R-68

Canopy Seal Regulator-Flow Illustrations.

Answer the statements as true (T) or false (F).

a. The canopy seal regulator controls air to the canopy seal.

b. The regulator maintains a pressure of 20 to 24 psi in the seal.

c. Engine bleed air is used as a source of air pressure to the canopy seal regulator.

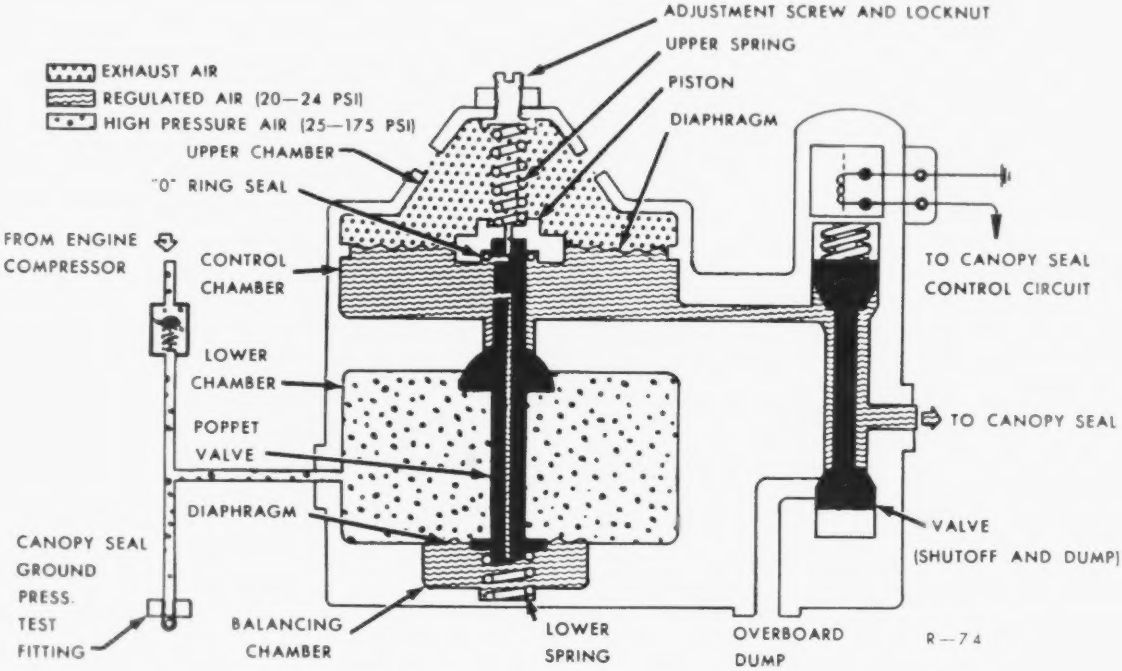
d. The voltage needed to energize the solenoid is 28V DC.

e. The regulator is a combination regulator, shutoff valve, and damp valve.

Answers to Frame 11: a. T , b. T , c. T , d. T , e. T

Frame 12

Look at the diagram as we discuss operation of the regulator with the canopy closed. Locate the shutoff and dump valve, upper chamber, control chamber, lower chamber and balancing chamber. When the canopy is closed, it energizes the solenoid. The solenoid can then pull the shutoff and dump valve UP. In this position the shutoff part of the valve opens a port for air to flow to the seal. The flow of air is from the control chamber of the regulator. The dump part of the valve will close the overboard dump port. Pressurized engine bleed air flows to the lower chamber. The top spring will force the poppet valve down and away from the seat. This takes place when there is not enough air pressure on the bottom side of the two diaphragms. Air can then flow into the control chamber and balancing chamber. When the pressure in these two chambers overcomes spring tension the poppet valve will close. This shuts off the flow of air to the canopy seal and keeps a pressure of 20 to 24 psi in the seal.


ADJUSTMENT SCREW AND LOCKNUT
UPPER SPRING
PISTON
DIAPHRAGM
EXHAUST AIR
REGULATED AIR (20—24 PSI)
HIGH PRESSURE AIR (25—175 PSI)
UPPER CHAMBER
"O" RING SEAL
FROM ENGINE COMPRESSOR
CONTROL CHAMBER
TO CANOPY SEAL CONTROL CIRCUIT
LOWER CHAMBER
TO CANOPY SEAL
POPPET VALVE
DIAPHRAGM
VALVE (SHUTOFF AND DUMP)
CANOPY SEAL GROUND PRESS. TEST FITTING
BALANCING CHAMBER
LOWER SPRING
OVERBOARD DUMP
R—74

Canopy Seal Regulator-Inflating.

Answer the statements as true (T) or false (F).

a. EBA (engine bleed air) is applied to the lower chamber.

b. The upper spring closes the poppet valve.

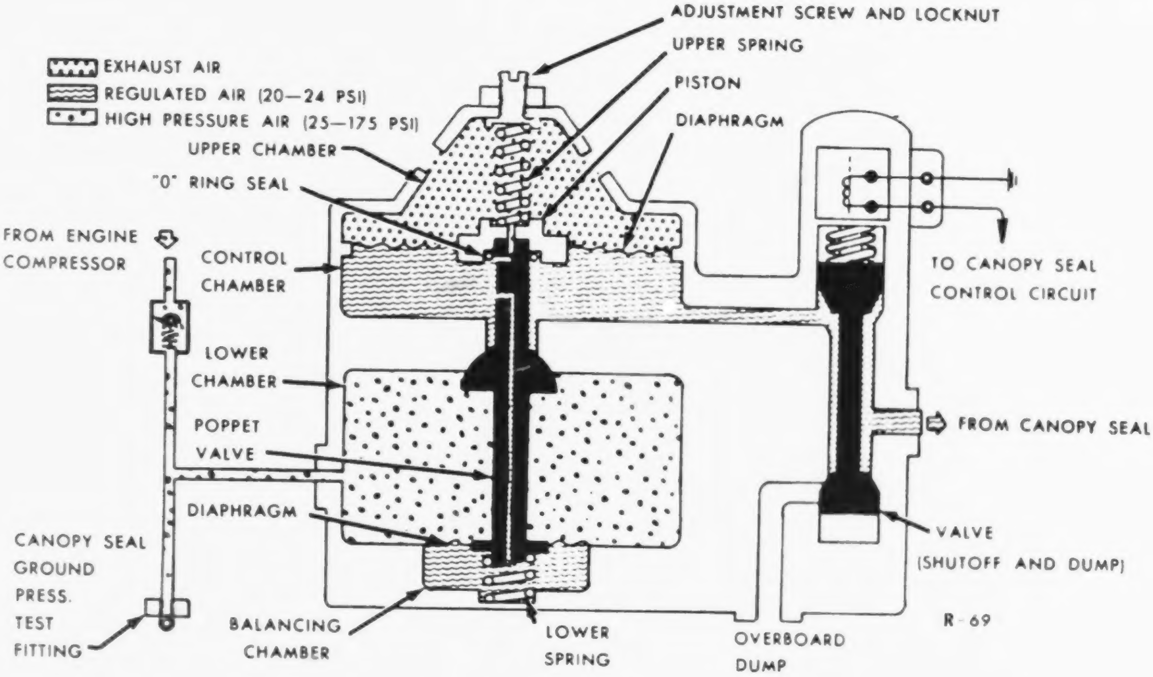
c. The poppet valve closes when the upper spring compresses.

d. When the poppet valve closes there is a pressure of 20 - 24 psi in the seal with the solenoid energized.

Answers to Frame 12: a. T , b. F , c. T , d. T

Frame 13

Look at the diagram as we discuss operation of the system with the canopy open. When the canopy is opened the solenoid is deenergized. The spring can then push the shutoff and dump valve down. The shutoff part of the valve stops the flow of regulated air to the seal. Air in the seal can flow past the dump part of the valve and will vent overboard.



EXHAUST AIR
REGULATED AIR (20—24 PSI)
HIGH PRESSURE AIR (25—175 PSI)
ADJUSTMENT SCREW AND LOCKNUT
UPPER SPRING
PISTON
DIAPHRAGM
UPPER CHAMBER
"O" RING SEAL
FROM ENGINE COMPRESSOR
CONTROL CHAMBER
LOWER CHAMBER
POPPET VALVE
DIAPHRAGM
CANOPY SEAL GROUND PRESS. TEST FITTING
BALANCING CHAMBER
LOWER SPRING
OVERBOARD DUMP
TO CANOPY SEAL CONTROL CIRCUIT
FROM CANOPY SEAL
VALVE (SHUTOFF AND DUMP)
R-69

Canopy Seal Regulator-Deflating.

Answer the statements as true (T) or false (F).

a. When the canopy is opened the solenoid deenergizes.

b. When the solenoid deenergizes, spring tension opens the dump valve and closes the shutoff valve.

c. When the solenoid energizes, the dump valve closes and the shutoff valve opens.

d. When the solenoid deenergizes the air flows from the canopy seal to the overboard dump.

Answers to Frame 13: a. __T__, b. __T__, c. __T__, d. __T__

Frame 14

That is about it for the canopy seal system. The next thing you will do is adjust the canopy seal regulator. You will do this in the next project.

No Response Required

CANOPY SEAL SYSTEM

Frame 1

a____ b____ c____ d____ e____ f____

Frame 2

a____ b____ c____

Frame 3

a____ b____ c____ d____

Frame 4

a____ b____ c____

Frame 5

a____ b____ c____

Frame 6

a____ b____ c____ d____

Frame 7

a____ b____ c____ d____

Frame 8

a____ b____ c____

Frame 9

a____ b____ c____ d____

Frame 10

1____ 2____ 3____ 4____ 5____

Frame 11

a____ b____ c____ d____ e____

Frame 12

a____ b____ c____ d____

Frame 13

a____ b____ c____ d____

Frame 14

No Response Required

RESPONSE SHEET 3ABR42331-PT-314

CANOPY SEAL SYSTEM

Frame 1

a____ b____ c____ d____ e____ f____

Frame 2

a____ b____ c____

Frame 3

a____ b____ c____ d____

Frame 4

a____ b____ c____

Frame 5

a____ b____ c____

Frame 6

a____ b____ c____ d____

Frame 7

a____ b____ c____ d____

Frame 8

a____ b____ c____

Frame 9

a____ b____ c____ d____

Frame 10

1____ 2____ 3____ 4____ 5____

Frame 11

a____ b____ c____ d____ e____

Frame 12

a____ b____ c____ d____

Frame 13

a____ b____ c____ d____

Frame 14

No Response Required

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-WB-314
10 February 1983

MAINTENANCE OF CANOPY SEAL REGULATORS

OBJECTIVES

1. Using the electric-pneumatic components trainer, the necessary handtools and the applicable TO, bench check a canopy seal pressure regulator with a maximum of two instructor assists.

2. Inspect a canopy seal air regulator in accordance with the TO and list two (2) of three (3) discrepancies.

Note: An instructor assist is defined as limited aid, such as technical direction or explanation or technical order interpretation given a student who can proceed no further on his/her own.

EQUIPMENT

Canopy Seal Regulator P/N 10752
Electrical Pneumatic Trainer #3038
4-Inch Common Screwdriver
3/8-Inch Open-End Wrench
TO 16R1-4-2-3

PROCEDURE

REMOVE YOUR JEWELRY

1. Your instructor will assign you an electrical pneumatic trainer P/N 3038.

2. Go to equipment locker number 2 and get a canopy seal regulator P/N 10752.

3. Sign out TO 16R1-4-2-3 from the TO file.

a. In the TO find the Leading Particulars for the regulator and complete the following statements.

Supersedes 3ABR42331-WB-314, 18 May 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 350; DAV - 1

RGL: N/A

Designed for ATC Course Use. Do Not Use on the Job.

(1) Maximum inlet pressure for Regulator P/N 10752 is ______________.

(2) Regulator outlet pressure for P/N 10752 is ______________.

b. Using the TO find the inspection requirements and answer the following statements.

(1) Inspect all parts for evidence of ____________, ______________, and ______________.

(2) Inspect all threaded areas for _________, __________, __________, or ___________________________.

c. Visually inspect your regulator and list any discrepancies below.

____

____

____

d. TO paragraph 5, items a and b, would be followed to repair and/or replace any parts which do not meet inspection requirements.

e. Have the instructor check your answers.

4. Trainer preparation.

a. Place switches S1 and S2 in the OFF position.

b. Plug the trainer power cables in the proper wall receptacle. Make sure that all circuit breakers on the left end of the trainer are pushed in.

5. Test procedures.

a. Refer to the hookup shown in figure 1 to complete the following steps.

b. Connect the two wires on the regulator to the correct electrical pins on the trainer electrical patch panel. Note: It does not matter which wire of the solenoid goes to D or R on the trainer electrical patch panel.

c. The hoses are indicated by heavy black lines in figure 1. Get the hoses from the bottom of the trainer. Connect the hoses to the regulator as shown. Do Not use a wrench to tighten the "B" nut as finger tightness is sufficient for this test.

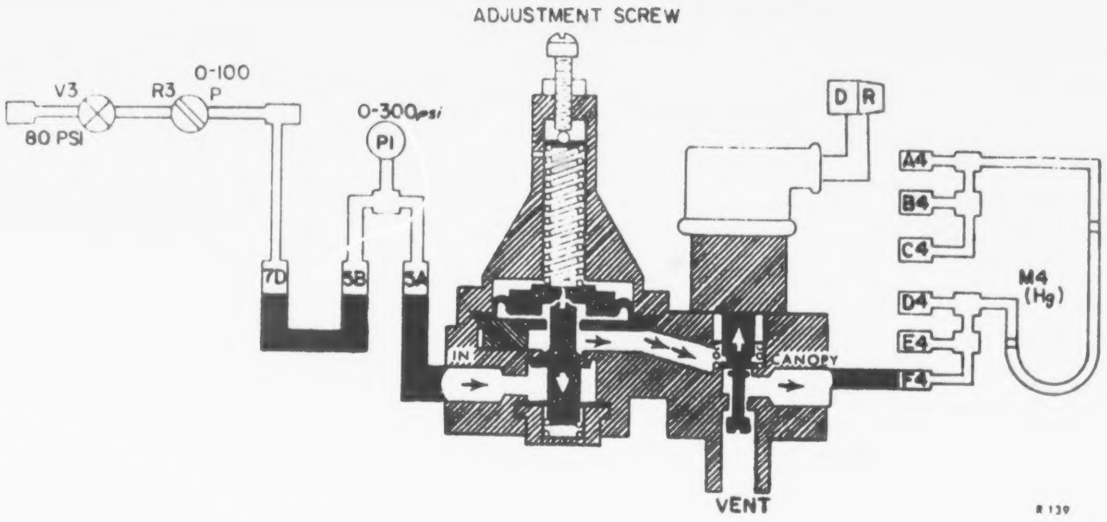


Figure 1.

d. Remove the plug from the vent port of the valve. Then have your instructor check your hookup before continuing.

e. Place the M4 manometer to the pounds and tenths scale. This scale begins with zero.

f. Place switch S1 in the "ON" position. DC voltmeter will read 25 ± 5 volts. Switch S2 will remain in the "OFF" position.

g. Open valve V3 (counterclockwise).

h. Turn R3 clockwise until gage P1 reads 50 psi. At this point we are simulating the aircraft engine that is operating with the canopy open. The canopy seal regulator solenoid is deenergized leaving the canopy seal deflated.

i. Place switch S2 in position number 3. This energizes the canopy seal regulator solenoid or simulates closing of the canopy. If the regulator is adjusted correctly, manometer M4 will read 20 to 24 psi. This is the amount of pressure actually going inside the canopy seal. If the reading on manometer M4 is not between 20 to 24 psi you will have to adjust the canopy seal regulator. Adjustment procedures can be found on page 3, paragraph 8b, of the TO. Make any adjustments now if necessary. Refer to figure 1 in this workbook to find the adjustment screw. Have your instructor check your manometer reading.

j. Move switch S2 between position "3" and "OFF" several times. The "OFF" position will deenergize the solenoid letting the seal deflate and the manometer read zero. This is to check for a sticking solenoid.

BEST COPY AVAILABLE

k. Place switch S2 in the "OFF" position.

l. Turn R3 counterclockwise until pressure gage P1 reads zero.

m. Turn valve V3 clockwise until closed.

n. Place switch S1 in the "OFF" position.

o. Disconnect canopy seal regulator, install vent cap and return the valve to locker #2.

p. Cap all air ports, plug all hoses, and return air hoses to bottom of trainer.

q. Unplug the trainer and report to the instructor. Have him check your work area before you leave.

Assists: 1. ______ 2. ______

Instructor's Signature ________________

PROGRAMMED TEXT
3ABR42331-PT-315

Technical Training

Aircraft Environmental Systems Mechanic

PRESSURIZATION PRINCIPLES

7 August 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 9.4

OBJECTIVES

1. Relate the terms associated with the operation of the cabin pressurization system with 80% accuracy.

2. Relate the components of the cabin pressurization system to their operations with 80% accuracy.

INSTRUCTIONS

This programmed text presents information in small steps called "frames." After reading each step, you are asked to complete a statement, match statements, or respond in some other way. Read the material and make your response as directed by the frame. DO NOT MARK IN THIS TEXT. After you have made your response, compare your answer with the correct answer found at the top of the next even numbered page. Should you respond incorrectly, reread the frame to clarify the information, then continue. If necessary, you may go back to check a fact or a principle, but do not skip ahead unless you are told to do so in the package.

Use this simple rule: READ--RESPOND--CONFIRM--ADVANCE.

You will not be graded on how fast you complete this material. You will be tested on what you have learned.

Supersedes 3ABR42331-PT-315, 19 November 1980.
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3370 TCHTG/TTGU-P - 1000; DAV - 1

As long as a pilot flies close to sea level (where he was designed to be), atmospheric pressure will force nitrogen, oxygen and other gases into his lungs and throughout his body. He needs the right amount of these gases to function. He needs them to live. However, as a plane gains altitude, atmospheric pressure goes down. The pilot gets to a point in his flight where there is not enough pressure. Low atmospheric pressure will not force the gases he needs through his system and his body will fail. Now he is faced with a real problem. At high altitudes his body functions become so affected that he has periods of dizziness, muscular weakness and at times severe pain.

Lack of oxygen can cause poor vision, increased heartbeat, dizziness, and muscle fatigue. Any of the symptoms are known as hypoxia.

Nitrogen starts to bubble at very low pressure. The bubbles, as they pass through the body, cause much pain in the muscles and joints. This symptom is known as the "bends." The bubbles in the blood that pass through the chest area cause difficulty in breathing. This is known as the "chokes." As the bubbles work their way through body tissues, skin blotches and itching occur and this is called the "creeps."

So, it is not a matter of what IS there at high altitudes that does cause discomfort, but rather, what is NOT there. And the important thing that is not there, is atmospheric pressure. To fix this problem aircraft crew compartments (cabin, cockpit) have been pressurized.

Answer the statements as true (T) or false (F).

1. High altitudes have no effect on the human body.
2. Atmospheric pressure is needed to force the necessary gases through the body.
3. As altitude is decreased, atmospheric pressure is increased.
4. Oxygen begins to bubble at a very low pressure.
5. The "bends" is caused by lack of nitrogen.
6. The absence of nitrogen and oxygen at high altitudes is what causes the body to fail.
7. If man is to fly and function at high altitudes, he must stay within a pressurized compartment.
8. The terms crew compartment, cockpit, and cabin, have the same meaning.

CORRECT RESPONSES TO FRAME 1: 1. F 2. T 3. T 4. F 5. F 6. T 7. T 8. T

Frame 2

To help you see the relationship between atmospheric pressure and altitude, table 1 was made. You can see that an increase in altitude will result in a decrease in atmospheric pressure. The chart is a simplified version of a more complicated technical order chart.

Altitude	ATM PRES (PSIA)	Altitude	ATM PRES (PSIA)	Altitude	ATM PRES (PSIA)
-1,000	15.23	21,000	6.48	43,000	2.36
Sea Level	14.69	22,000	6.21	44,000	2.25
1,000	14.17	23,000	5.95	45,000	2.15
2,000	13.66	24,000	5.70	46,000	2.05
3,000	13.17	25,000	5.46	47,000	1.95
4,000	12.69	26,000	5.22	48,000	1.86
5,000	12.23	27,000	5.00	49,000	1.77
6,000	11.77	28,000	4.78	50,000	1.70
7,000	11.34	29,000	4.57	51,000	1.61
8,000	10.91	30,000	4.37	52,000	1.54
9,000	10.50	31,000	4.18	53,000	1.46
10,000	10.10	32,000	3.99	54,000	1.39
11,000	9.72	33,000	3.81	55,000	1.33
12,000	9.34	34,000	3.63	56,000	1.27
13,000	8.99	35,000	3.47	57,000	1.21
14,000	8.63	36,000	3.30	58,000	1.15
15,000	8.29	37,000	3.15	59,000	1.10
16,000	7.96	38,000	3.00	60,000	1.05
17,000	7.65	39,000	2.86	70,000	.648
18,000	7.34	40,000	2.73	80,000	.404
19,000	7.05	41,000	2.60	90,000	.252
20,000	6.76	42,000	2.48	100,000	.160

Table 1. Relation Between Altitude and Atmospheric Pressure.

Using table 1 and the response sheet, fill in the blanks showing atmospheric pressure at various altitudes.

1. ______________________________ sea level.
2. ______________________________ 12,000 ft.
3. ______________________________ 25,000 ft.
4. ______________________________ 50,000 ft.
5. ______________________________ 100,000 ft.

At what altitude would the aircraft be if atmospheric pressure is:

6. 8.99 psi______________________________.
7. 6.76 psi______________________________.
8. 2.60 psi______________________________.
9. 1.05 psi______________________________.
10. .252 psi______________________________.

Frame 3

We now know that the aircraft cabin must be pressurized for high altitude flying. Let us find out where we get the pressure. Is the cabin pressurized by some sort of air compressor before flight? Do the crew members take bottles of air pressure with them? Is there a system on the plane that makes the pressure? All of these ideas could be right. A system on the aircraft is felt to be the best method of pressurizing.

Most planes that fly at great heights are run by jet engines. The engine compressor section supplies air pressure for operation of various systems on the plane. One of the systems that is run by engine bleed air (EBA), from the engine compressor section, is the air conditioning system. This system, in turn, supplies a flow of air to heat, cool, and pressurize the cabin. So, if the air conditioning system fails, cabin pressurization will be lost.

Answer the statements as true (T) or false (F).

1. Most aircraft that fly at high altitudes are jet powered.
2. The compressor section is a feature of a jet engine.
3. The air conditioning system is driven by air from the engine compressor section.
4. The air conditioning system supplies air for cabin pressurization.
5. Failure of the air conditioning system will have no effect on cabin pressurization.

CORRECT RESPONSES TO FRAME 2: 1. 14.69 2. 9.34 3. 5.46 4. 1.70 5. .160 6. 13,000 7. 20,000 8. 41,000 9. 60,000 10. 90,000

CORRECT RESPONSES TO FRAME 3: 1. T 2. T 3. T 4. T 5. F

Frame 4

You must be familiar with some terms used with cabin pressurization. The terms defined below will be used in your training on pressurization principles. It is important that you learn the meaning of each term. If you do not, the rest of this text and others to follow will be hard for you to understand.

1. PSIG - Pounds per square inch gage. The pressure shown on a gage. Does not include atmospheric pressure.

2. PSIA - Pounds per square inch absolute, in reference to zero. To find PSIA, take the pressure shown on a gage and add the atmospheric pressure to it.

3. PSID - Pounds per square inch differential. This is the difference in two pressures. For example: cabin pressure is 12 PSIA and atmospheric pressure is 9 PSIA. The PSID is 3 PSI.

4. Engine Bleed Air (EBA) - This is the supply of air that comes from the engine compressor section. The engine bleed air drives the air conditioning system.

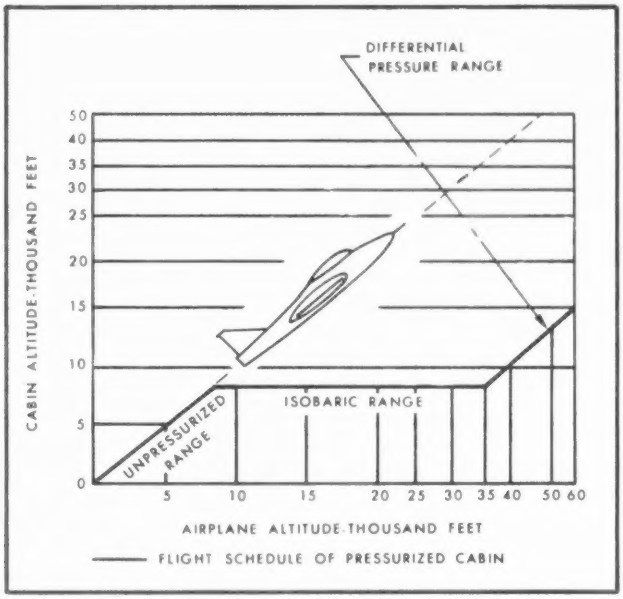
5. Atmospheric Pressure - The pressure of the air mass surrounding the earth. At sea level this pressure is approximately 14.7 psi and it decreases as altitude increases.

6. Cabin Pressure - The amount of air pressure inside the aircraft cabin or crew compartment.

7. Aircraft Altitude - The exact height at which the aircraft is located. Measured in feet from sea level up. This altitude can be found if you know the cabin altitude and the differential pressure. Here is how it works: the cabin altitude is 20,000 feet, that is equal to a pressure of 6.76 psia. The differential pressure is 4.0 psid. You know that 4.0 psid means that the pressure in the cabin is 4.0 psi more than the atmospheric pressure. You would then subtract 4.0 psid from 6.76 psia, that leaves 2.76 psia. This is the atmospheric pressure. The 2.76 psia is equal to an altitude of approximately 40,000 feet, the aircraft altitude.

8. Cabin Altitude - A comparison of cabin pressure to atmospheric pressure at various altitudes. This altitude can be found if you know the aircraft altitude and the differential pressure. For example: Let us say, the aircraft altitude is 50,000 feet, that is equal to a pressure of 1.7 psia. The differential pressure is 5.0 psid. In this case, you would have to add 5.0 psid to 1.7 psia. 5.0 psia plus 1.7 psia is equal to 6.7 psia. The 6.7 psia is equal to a cabin altitude of approximately 20,000 feet.

9. Isobaric Range - Two points in cabin altitude between which cabin pressure remains constant. One point is where cabin pressurization begins and the other point is where the constant pressure ends and differential pressure takes over. See figure 1. Notice that there are three ranges of cabin pressurization.



PRESSURIZATION SCHEDULE N-453

Figure 1.

10. Aneroid or Evacuated Bellows - A metallic bellows from which all air has been removed. It is sealed so no pressure can get in or out. The aneroid is sensitive to changes in atmospheric pressure. The aneroid reacts to atmospheric pressure above

and below 10 psi. A guide spring inside the aneroid sets this pressure. When atmospheric pressure is above 10 psi the aneroid will contract. When atmospheric pressure is below 10 psi the aneroid will expand.

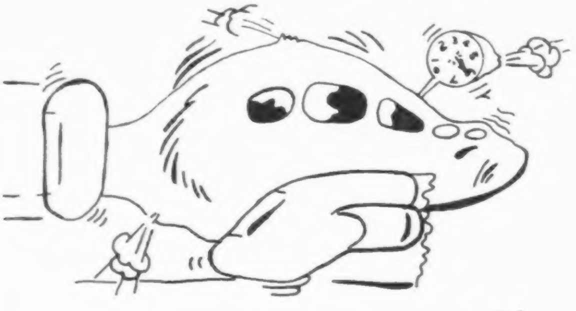
11. Low Differential - A feature of certain cabin pressure regulators which maintains a low pressure differential between the cabin pressure and atmospheric pressure while the aircraft is in a combat area.

12. High Differential - A feature of some cabin pressure regulators which maintains a high pressure differential between cabin pressure and atmospheric pressure. Usually found on noncombat type aircraft.

Answer the statements as either true (T) or false (F).

1. Engine bleed air comes from the engine exhaust section.
2. PSID is gage pressure plus atmospheric pressure.
3. Cabin altitude has to be the same as aircraft altitude.
4. Aneroid bellows are filled with air and expand under high pressure.
5. During the isobaric range cabin pressure remains constant.

The air conditioning system always pumps air into the cabin. Pressurization will get too high if some sort of control is not used.



N-454

Figure 2.

There is one type of control which is built in. This is what is known as normal leakage. Even though the cabin is sealed, some air still can get out around cables, fittings, and joints in the metal panels. This leakage is not enough to stop overpressurization. The air conditioning system puts out a greater flow of air than the normal leakage can take care of.

In addition to normal leakage, most planes use a device known as a cabin pressure regulator. This unit is put in the aircraft cabin and it vents to the outside (atmosphere). Its function is simple. When cabin pressure gets too low (minimum), the regulator will close the vent to the outside. This will allow the air conditioning system to build up the pressure. If pressure starts to go too high (maximum), the regulator will open the vent. Excessive pressure is dumped into the atmosphere.

Answer the statements as true (T) or false (F).

1. Cabin pressure is supplied by the air conditioning system.
2. All aircraft cabins have a certain amount of normal leakage.
3. Normal leakage cannot effectively control cabin pressure.
4. The cabin pressure regulator is actuated by cabin air temperature.
5. The cabin pressure regulator is located inside the aircraft cabin.

CORRECT RESPONSES TO FRAME 4: 1. F 2. F 3. F 4. F 5. T

CORRECT RESPONSES TO FRAME 5: 1. T 2. T 3. T 4. F 5. T

Frame 6

You now have a general idea of what a cabin pressure regulator does. Let us take a close look to see just how one works. There are several types of regulators and some of them are complicated. All of them are made to automatically control cabin pressure. By controlling pressure, the plane can fly at various altitudes and the pilot or flight crew will not have any discomfort due to improper pressurization.

Most regulators have two main parts; (1) the regulator, and (2) the outflow valve. These two parts are sometimes put together as one unit or they may be mounted in different places in the cabin and connected by air lines (tubing).

Answer the statements as true (T) or false (F).

1. There are several types of cabin pressure regulator assemblies.
2. Cabin pressure regulator assemblies automatically control cabin pressure.
3. Most regulator assemblies are made up of only one main part.
4. The regulator and outflow valve must be mounted at separate locations in the cabin.
5. The regulator and outflow valve may be bolted together as one unit.

The regulator assembly is installed INSIDE the cabin. The outflow valve covers an opening in the aircraft skin. When the outflow valve is open, cabin air can flow out to the atmosphere. Refer to figure 3 as we talk about the outflow valve.

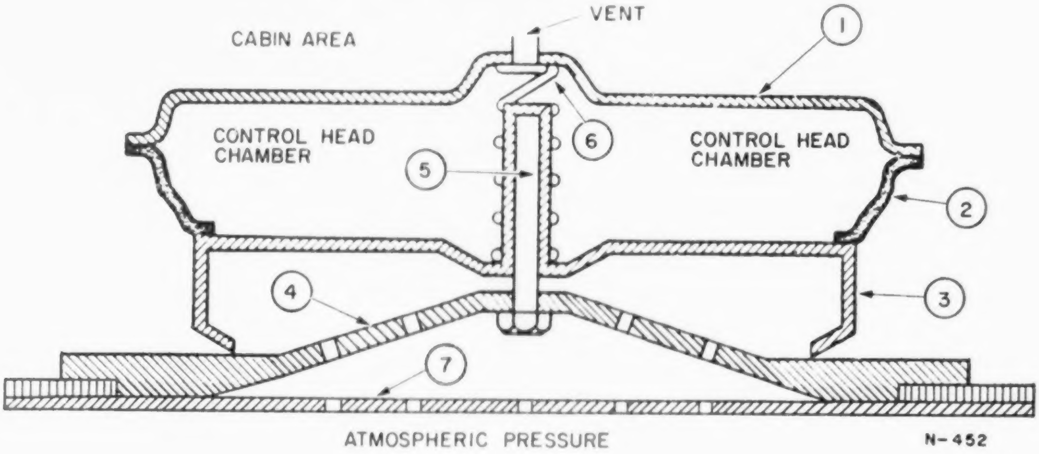


Figure 3.

In figure 3 the round outflow valve has been cut in half from top to bottom and you are looking into the open side of one half. Number one (1) is part of the valve housing. It bolts to the regulator (not shown) and does not move. Number two (2) is a rubberized diaphragm that allows the valve to move. Number three (3) is the valve (shown closed) and it moves up and down. Number four (4) is the lower part of the valve housing that bolts to the inside of the aircraft skin. Number five (5) is a guide bolt on which the valve slides up and down. Number six (6) is a spring which pushes down on the valve with about .3 pounds of force to help keep the valve on seat. Number seven (7) is the aircraft skin that has slits cut so that cabin pressure may vent to the atmosphere.

From the illustration, identify the name of each part of the outflow valve.

_____a. guide bolt.

_____b. upper valve housing

_____c. diaphragm

_____d. spring

_____e. valve

_____f. aircraft skin

_____g. lower valve housing

1041

CORRECT RESPONSES TO FRAME 6: 1. T 2. T 3. F 4. F 5. T

CORRECT RESPONSES TO FRAME 7: a. 5 b. 1 c. 2 d. 6 e. 3 f. 7 g. 4

Frame 8

When the plane is on the ground and the air conditioning system is off, cabin pressure and atmospheric pressure are both at 14.7 psi. The spring in the outflow valve will push down with a force of 0.3 pounds. This force plus the atmospheric pressure that comes in the control head chamber through the vent line, holds the outflow valve on seat. Total pressure is 15 psia (14.7 + 0.3). Cabin pressure (14.7 psia) does push up on the valve, but can not overcome the downward force of 15 psia.

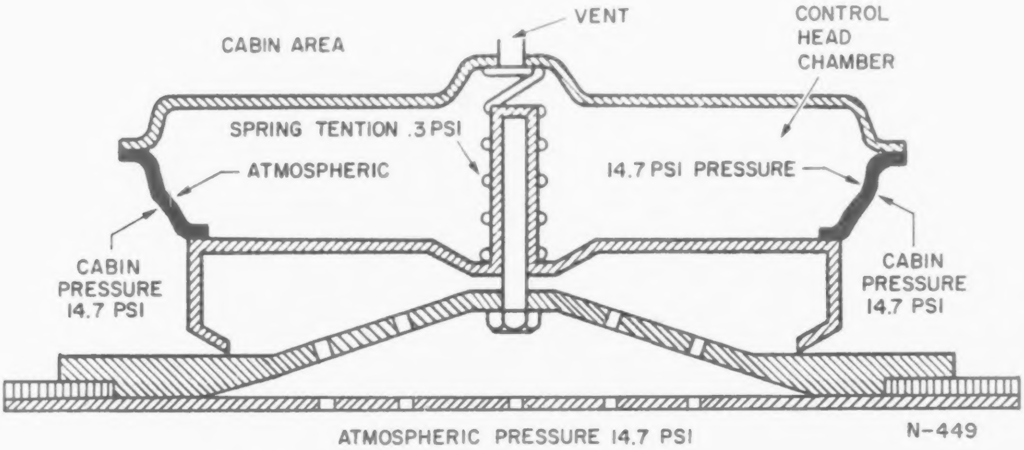

VENT
CABIN AREA
CONTROL HEAD CHAMBER
SPRING TENTION .3 PSI
ATMOSPHERIC
14.7 PSI PRESSURE
CABIN PRESSURE 14.7 PSI
CABIN PRESSURE 14.7 PSI
ATMOSPHERIC PRESSURE 14.7 PSI
N-449

Figure 4.

NO RESPONSE REQUIRED

1042

Frame 9

Before going any further, let's briefly review what has been covered thus far.

1. Cabin pressurization is needed for aircraft that fly at high altitudes.

2. Cabin pressurization is provided by the air conditioning system.

3. The air conditioning system is driven by air pressure from the engine compressor section.

4. Cabin pressure must be controlled to prevent it from becoming excessive. The most common control device used to control pressure is the cabin pressure regulator assembly.

5. The regulator assembly is always located inside the pressurized compartment (cabin).

6. The regulator assembly is made of two major parts, the outflow valve and the regulator.

7. The outflow valve opens and closes to allow cabin pressure to build up or be vented through louvers in the aircraft skin to the atmosphere.

8. Control head pressure is atmospheric pressure plus spring tension. This pressure tries to hold the outflow valve on seat.

9. Should cabin pressure exceed control head pressure it will offseat the outflow valve.

NO RESPONSE REQUIRED

CORRECT RESPONSES TO FRAME 8: None required.

CORRECT RESPONSE TO FRAME 9: None required.

Frame 10

The next part of the cabin pressure regulator assembly is the regulator. The type we will discuss sits on top of the outflow valve. The control head chamber of the outflow valve vents to the atmosphere through the regulator control head chamber.

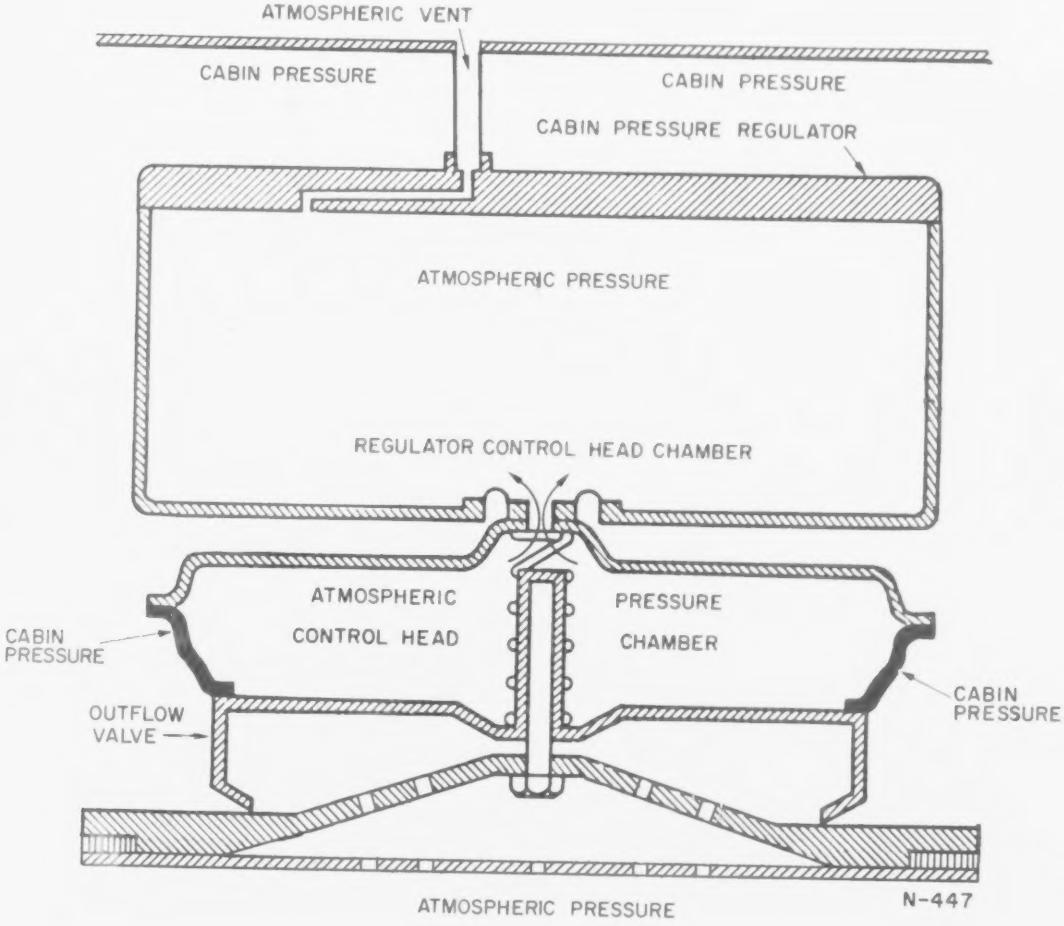

ATMOSPHERIC VENT
CABIN PRESSURE
CABIN PRESSURE
CABIN PRESSURE REGULATOR
ATMOSPHERIC PRESSURE
REGULATOR CONTROL HEAD CHAMBER
ATMOSPHERIC
CONTROL HEAD
PRESSURE
CHAMBER
CABIN PRESSURE
CABIN PRESSURE
OUTFLOW VALVE
ATMOSPHERIC PRESSURE
N-447

Figure 5.

The position of the outflow valve is

a. Open.

b. Closed.

1044

A filter and orifice have been added to the illustration. The orifice (bleed hole) is put in the control head of the regulator to let a small amount of cabin air flow in the control head of the regulator. The filter is used to keep dirt from plugging the orifice. Compare the size of the orifice with the atmospheric vent. The orifice is made smaller. Air can flow out through the vent faster than it can enter the control head through the orifice.

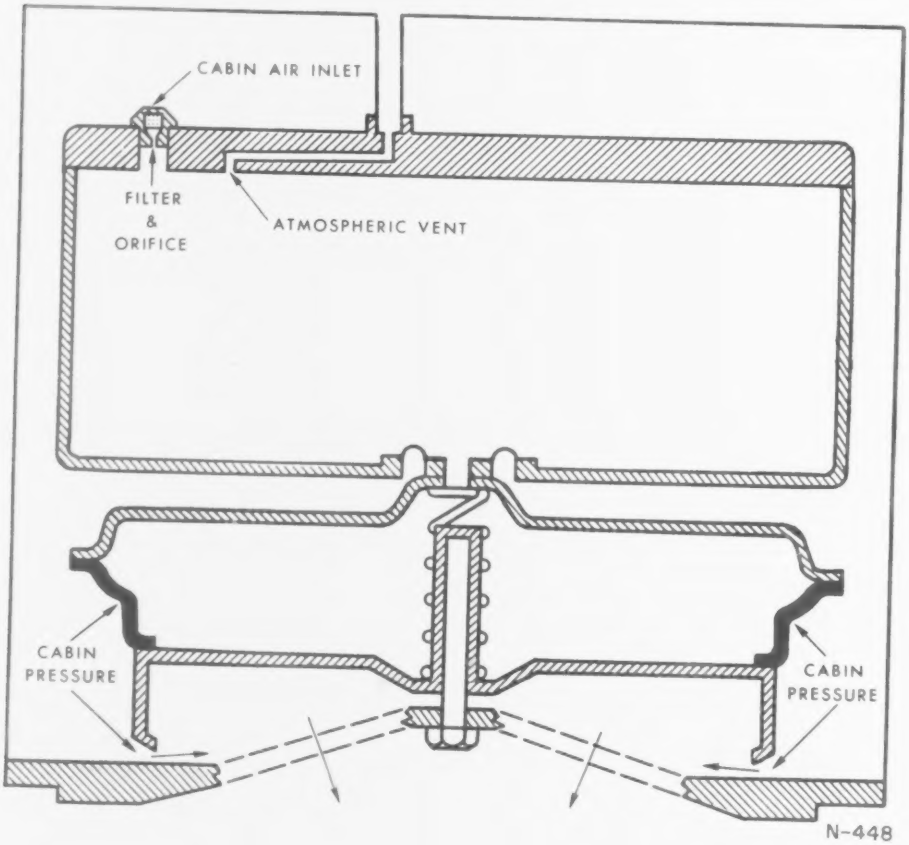

CABIN AIR INLET
FILTER & ORIFICE
ATMOSPHERIC VENT
CABIN PRESSURE
CABIN PRESSURE
N-448

Figure 6.

CORRECT RESPONSES TO FRAME 10: b

Frame 11 (Cont'd)

Answer the statements as true (T) or false (F).

1. Due to the size of the orifice, the pressure in the control head chamber will be relieved faster than it can be built up.

2. Reducing the control head pressure faster than it can be built up will let the cabin pressure open the outflow valve.

3. If the filter became clogged with dirt, the control head chamber pressure would reduce and the outflow valve would open.

4. Opening the outflow valve would reduce the cabin pressure by allowing the cabin air pressure to flow to the atmosphere.

Identify each part of the pressure regulator and outflow valve.

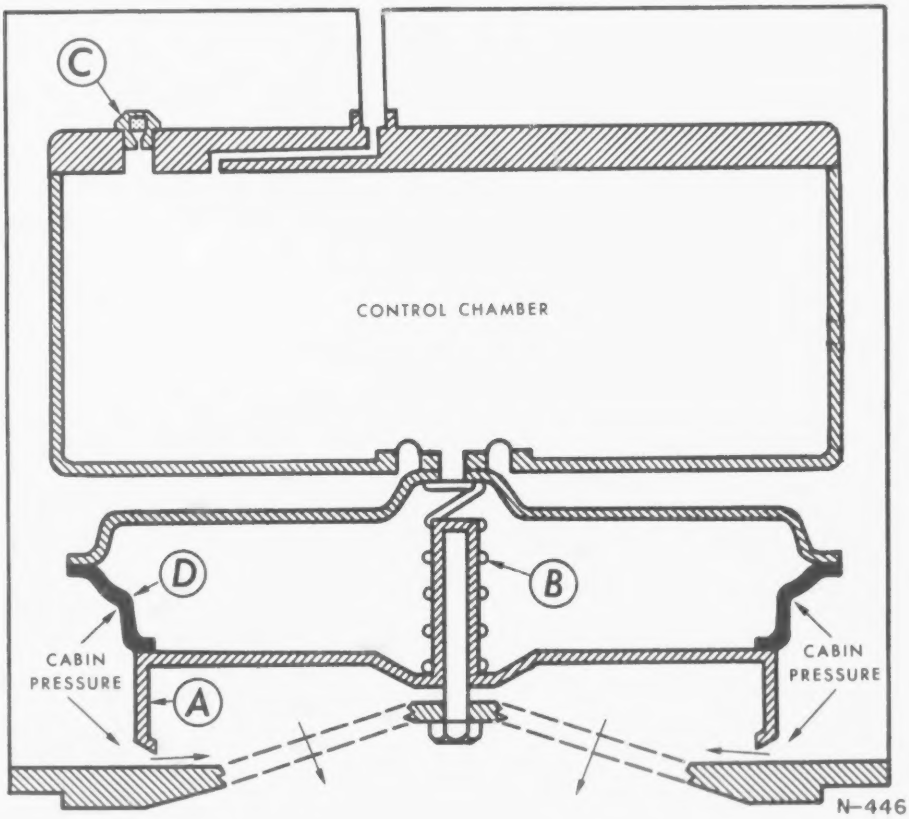


Figure 7.

A thin flexible disc attached to the outflow valve that separates cabin pressure from control head pressure.

Causes movement of the outflow valve.

Applies a pressure of .2 to .3 psi to the outflow valve to keep the outflow valve from chattering during its opening and closing cycles.

Controls the size of the opening in the aircraft skin.

Controls the amount of cabin pressure air flowing to the atmosphere.

Allows a metered amount of cabin air pressure to enter the control head of the cabin pressure regulator and prevents dirt from plugging or restricting the orifice.

CORRECT RESPONSES TO FRAME 11: 1. T 2. T 3. T 4. T

CORRECT RESPONSES TO FRAME 12: 1. D 2. D 3. B 4. A 5. A 6. C

Frame 13

The illustration shows that an aneroid, lever, fulcrum, and metering valve have been added. The spring tries to open the metering valve. In Frame 4 you were taught what an aneroid is and how it works.

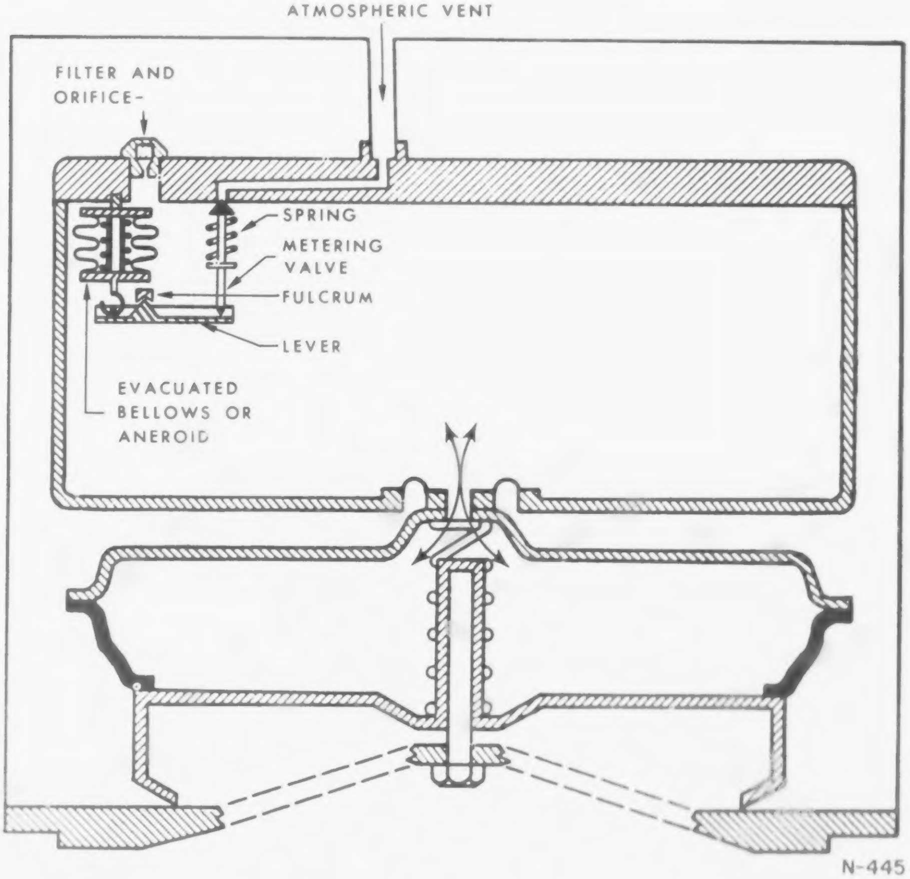

ATMOSPHERIC VENT
FILTER AND ORIFICE
SPRING
METERING VALVE
FULCRUM
LEVER
EVACUATED BELLOWS OR ANEROID
N-445

Figure 8.

NO RESPONSE REQUIRED

In the illustration, a spring has been hooked to the lever. One end of the spring is threaded onto a bolt. Turning the bolt adjusts the spring tension. This adjustment sets the altitude at which the aneroid will close the metering valve.

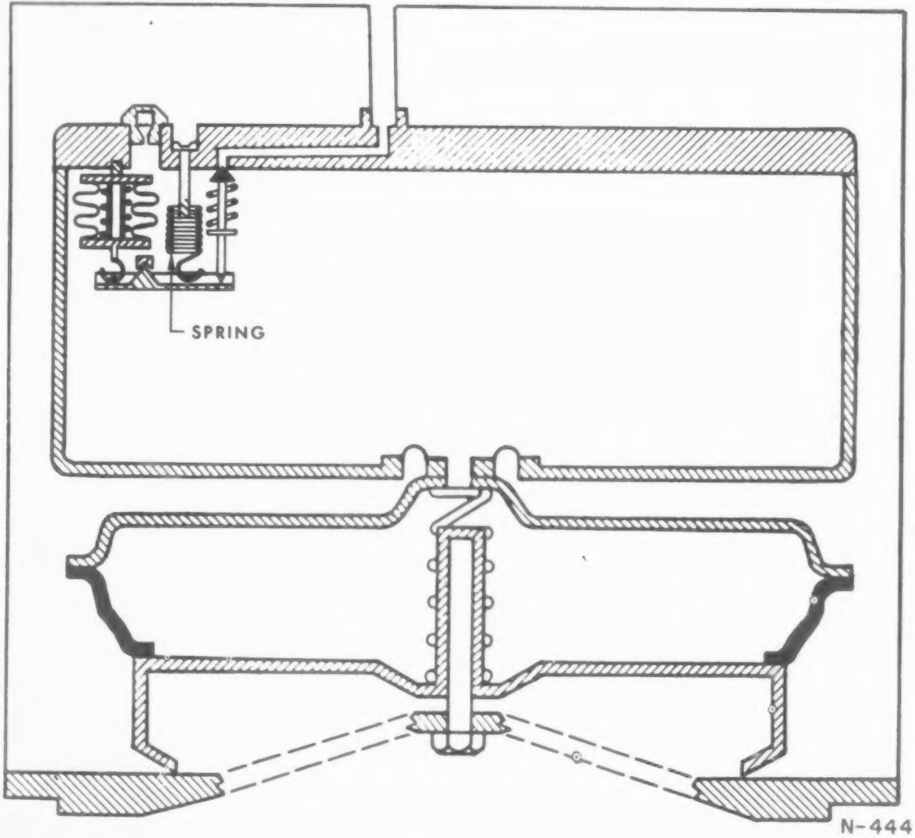


Figure 9.

Answer the statements as true (T) or false (F).

1. Spring tension tends to close the metering valve by pulling up on the lever.

2. Adjusting the spring tension determines the altitude at which the metering valve will close.

3. Compressing the aneroid closes the metering valve.

1049

CORRECT RESPONSES TO FRAME 13: None required.

CORRECT RESPONSES TO FRAME 14: 1. T 2. T 3. F

Frame 15

When the aneroid contracts (low altitude, high pressure) it pulls up on the lever and offseats the metering valve. This will let control head pressure in the regulator and outflow valve escape into the atmosphere. As control head pressure drops, the cabin pressure on the outside of the outflow valve will force the valve open. Air can then flow out the opening in the aircraft skin. This will cause a drop in cabin pressure. You can see that the aneroid has compressed, spring tension has been overcome and the metering valve has opened.

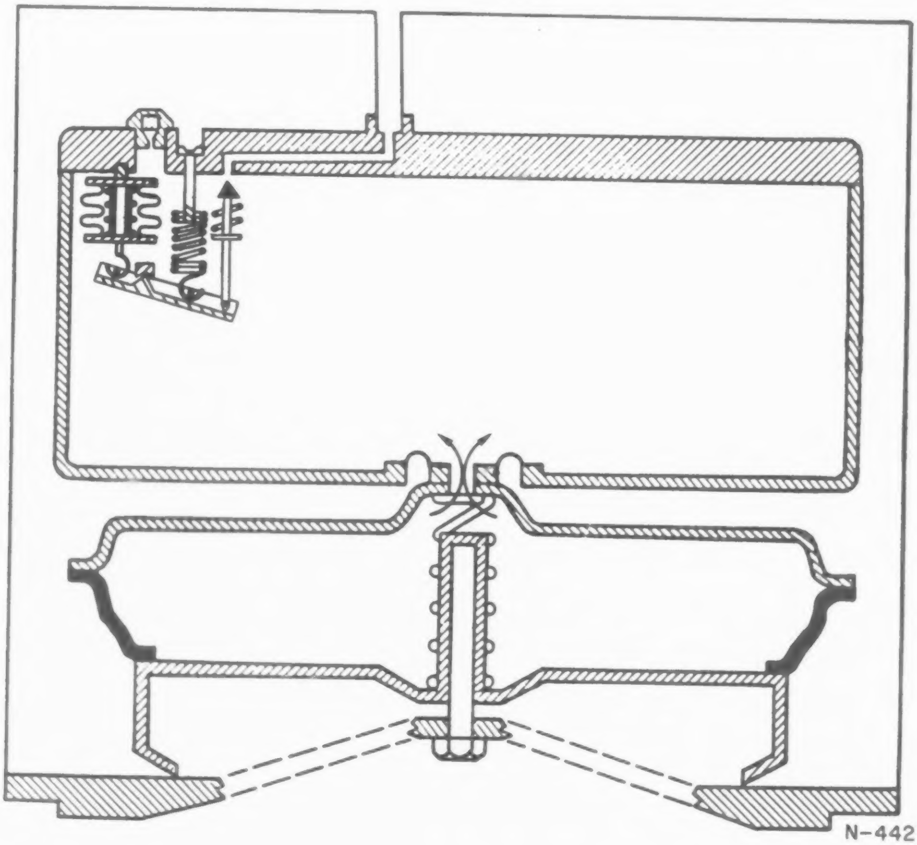


Figure 10.

Identify the statement that best describes the events that will occur following the opening of the metering valve.

a. The control head chamber pressure in both the regulator and the outflow valve will bleed to atmosphere. Pressure in the control head chamber of the outflow valve is reduced. The cabin pressure surrounding the outflow valve diaphragm will force the outflow valve open. Cabin pressure is drained to the atmosphere.

b. Control head pressure in both the regulator and the outflow valve will build up. The pressure in the control head chamber of the outflow valve increases. The control head pressure in the outflow valve is higher than the cabin pressure surrounding the outflow valve. The outflow valve will close and allow cabin pressure to build up.

CORRECT RESPONSES TO FRAME 15: a

Frame 16

In the illustration shown below, the aneroid has expanded and the spring has moved the metering valve to the closed position.

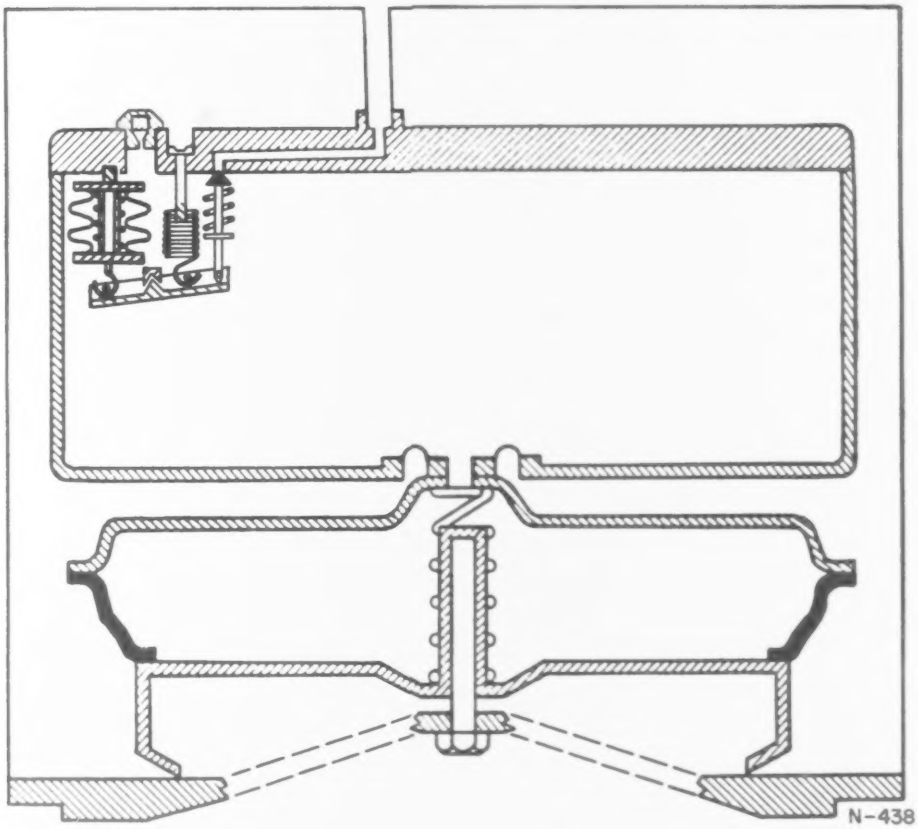


Figure 11.

Identify the statement that best describes the events that take place following the closing of the metering valve.

a. The control head chamber pressure in both the regulator and the outflow valve bleeds to atmosphere. Pressure in the control head chamber of the outflow valve is reduced. The cabin pressure surrounding the outflow valve diaphragm forces the outflow valve open. Cabin pressure is drained to the atmosphere.

b. The control head pressure in both the regulator and the outflow valve builds up. Pressure in the control head chamber of the outflow valve is increased. Since the control head pressure in the outflow valve is higher than the cabin pressure surrounding it, the outflow valve closes. Cabin pressure is allowed to build up.

The isobaric section is made up of the aneroid, spring, and metering valve. It does two things. It keeps the cabin from being pressurized until the plane gets to a preset height. Then it lets the cabin be pressurized but keeps the amount of pressure steady until the plane gets to a higher altitude. Go back to Frame 4 and look at figure 1. You will see three ranges of cabin pressurization; (1) unpressurized, (2) isobaric, and (3) differential. The isobaric section controls the first two of these.

Answer the statements as true (T) or false (F).

1. The isobaric section consists of an aneroid, an adjustable spring, and a metering valve.
2. The range of cabin pressurization at which a constant value is maintained is called the differential range.
3. There are at least three ranges in a cabin pressurization system.
4. The isobaric section of the cabin pressure regulator produces the first two ranges of cabin pressurization.

CORRECT RESPONSES TO FRAME 16: b

CORRECT RESPONSES TO FRAME 17: 1. T 2. F 3. T 4. T

Frame 18

The differential section is one of the main parts of a cabin pressure regulator. Its job is to take over control of cabin pressure when the isobaric section kicks out. In figure 1 (Frame 4) you can see that the isobaric range ends at 35,000 ft. When the differential section takes over it keeps a set differential between cabin and atmospheric pressure. The differential section is made up of just a few parts. One of them is the metering valve shown below.

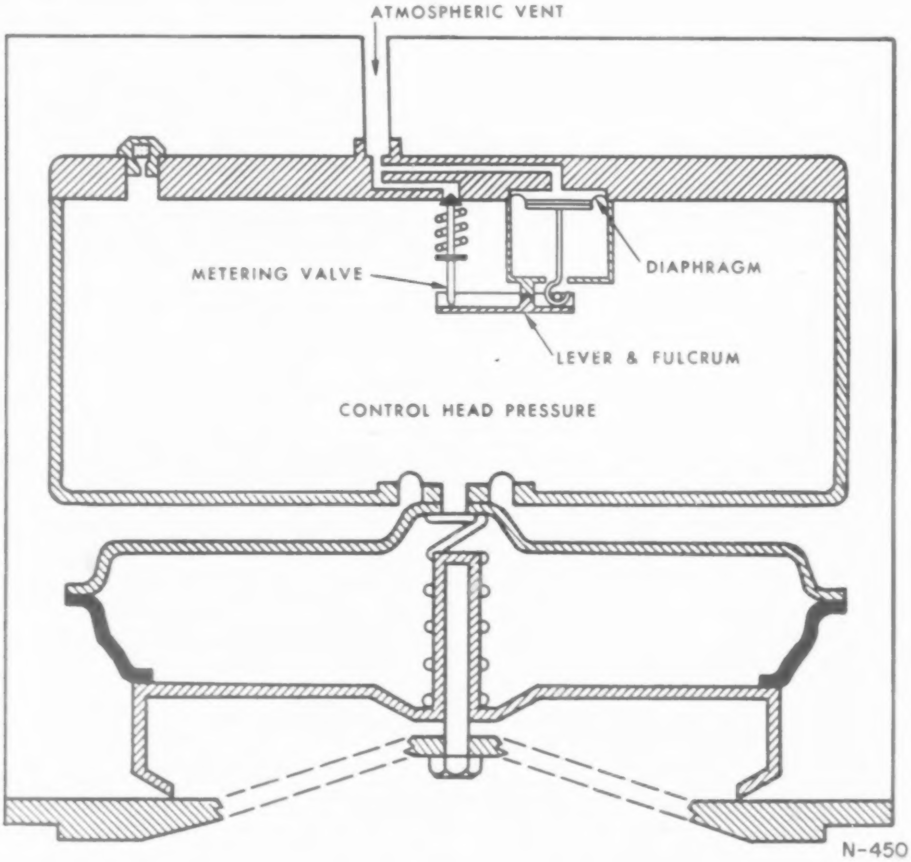


Figure 12.

The metering valve is moved on seat or off seat by the lever. The lever rocks up and down on a fulcrum (pivot point). The lever is moved by a piston which separates control head pressure from the vent port. The piston is moved up and down by a diaphragm. The diaphragm is pushed up or down by control head or atmospheric pressure whichever is greater.

Answer the statements as true (T) or false (F).

1. If the control pressure is higher than the atmospheric pressure, the diaphragm is forced up and the metering valve opens.

2. If atmospheric pressure is greater than control pressure, the diaphragm is forced down and the metering valve closes.

3. Opening the metering valve reduces control pressure so that the outflow valve may be opened.

4. Closing of the metering valve causes control chamber pressure to build up and close the outflow valve. Opening the metering valve causes control chamber pressure to decrease and allow the outflow valve to be opened.

5. Closing the metering valve decreases control chamber pressure and opens the outflow valve. Opening the metering valve increases control chamber pressure and closes the outflow valve.

COR.   NSES TO FRAME 18: 1. T 2. T 3. T 4. T 5. F

Frame

You can see in the illustration that a spring has been hooked to the lever. This spring, along with the atmospheric pressure pushing down on the diaphragm and piston, tries to keep the metering valve on seat. The spring is adjustable and should be set to keep a 5 psi differential between cabin and atmospheric pressures.

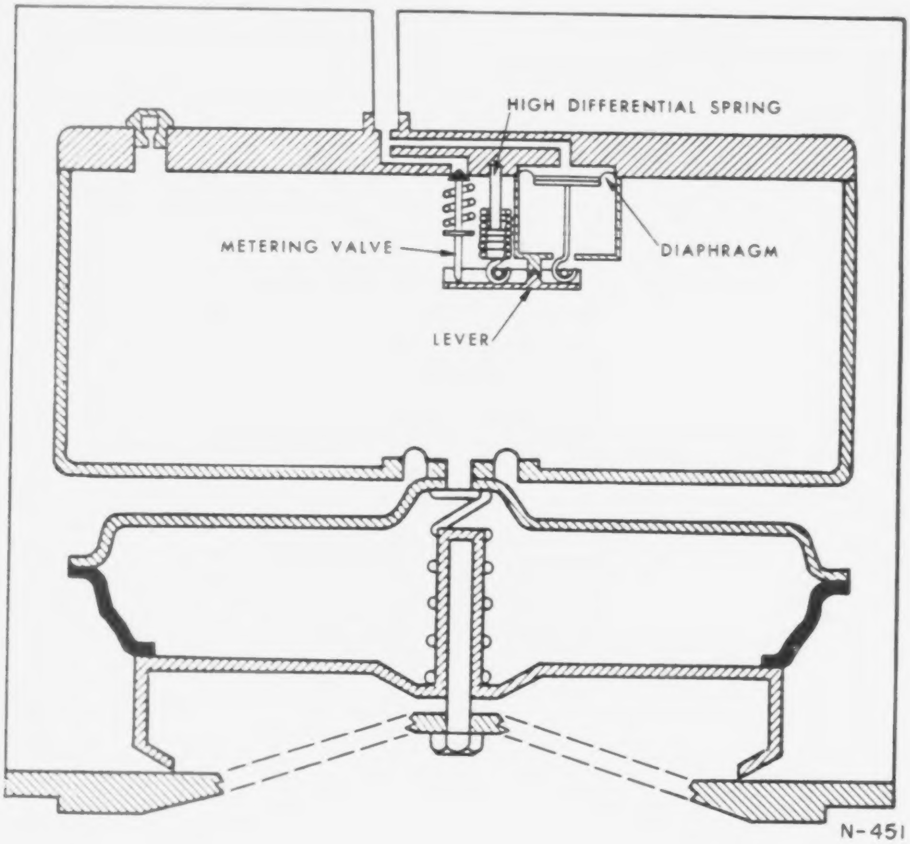


Figure 13.

Identify the statement which best describes the operation of the differential section.

a. To open the metering valve, control chamber pressure must be greater than the combined force of the differential spring and atmospheric pressure.

b. To open the metering valve, the combined force of the atmospheric pressure and spring tension must be greater than the control head chamber pressure.

Identify each part of the differential section.

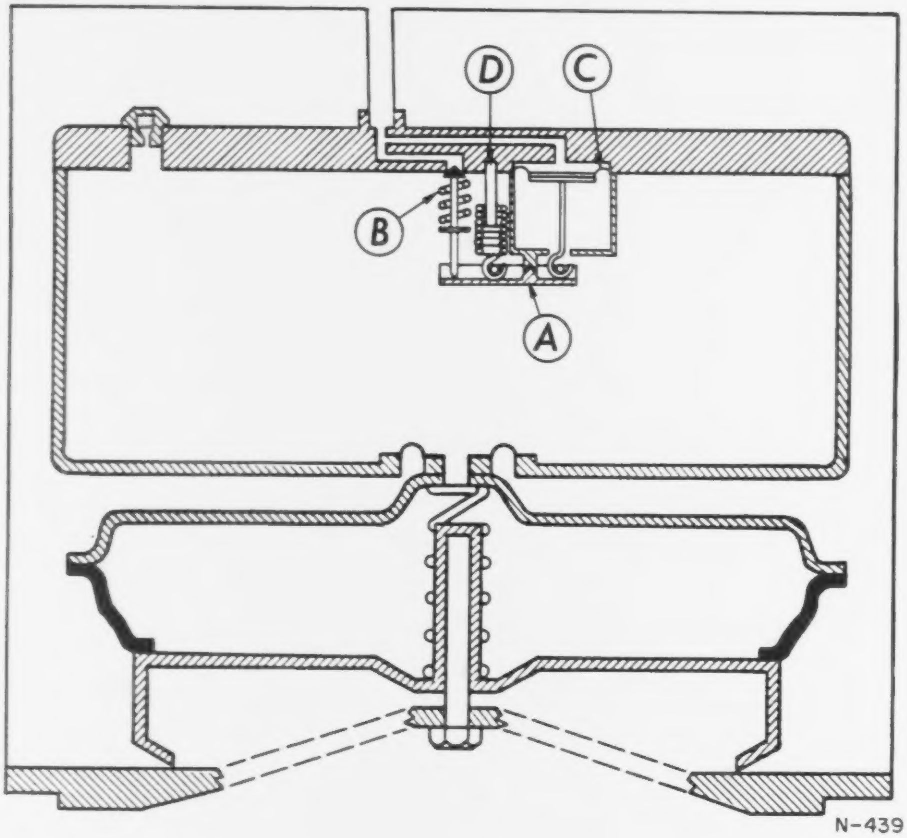


Figure 14.

1. Controls the amount of chamber pressure that bleeds to atmosphere thereby controlling the opening and closing of the outflow valve.

2. Separates atmospheric pressure from control head pressure.

3. Links the differential diaphragm and metering valve together so that the diaphragm can control the position of the metering valve.

4. Works with the atmospheric pressure on the top of the differential diaphragm to close the metering valve.

CORRECT RESPONSES TO FRAME 19: a

CORRECT RESPONSES TO FRAME 20: 1. B 2. C 3. A 4. D

Frame 21

Identify each part of the cabin pressure regulator and outflow valve.

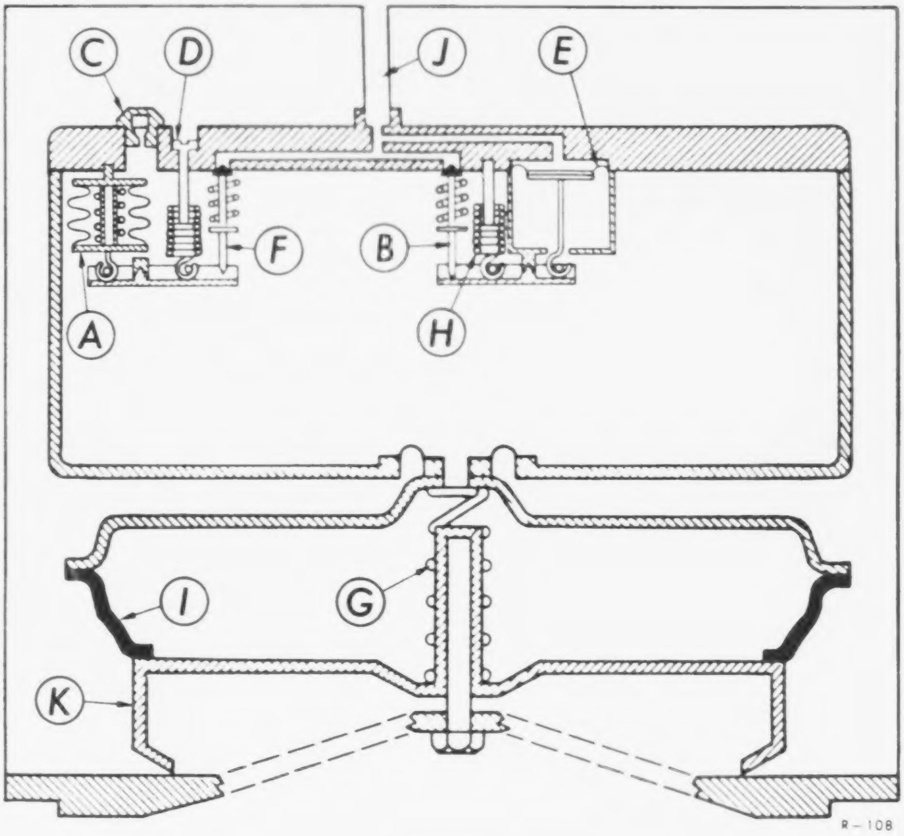


Figure 15.

1. Helps supply the force which tends to keep the outflow valve on seat.
2. Opens and closes to vent cabin pressure to the atmosphere.
3. Separates outflow valve control head pressure from cabin pressure.
4. Allows a small amount of cabin air pressure to enter the regulator control head chamber.
5. Aids the aneroid in applying the force to close the metering valve.
6. Vents control head pressure to the atmosphere when the aneroid is compressed.
7. Vents control head pressure to the atmosphere during operation of the differential section.

Frame 21 (Cont'd)

8. Is actuated by either control head pressure or atmospheric pressure.

9. Expands or contracts depending on aircraft altitude.

10. Aids the diaphragm and piston in positioning the differential metering valve.

CORRECT RESPONSES TO FRAME 21: 1. G 2. K 3. I 4. C
5. D 6. F 7. B 8. E
9. A 10. H

Frame 22

Now let's take everything we've talked about and put it all together as an operational system. Refer to foldout 1.

UNPRESSURIZED RANGE

1. Aircraft on the ground - The air conditioning is on. Cabin pressure builds up both inside and outside the regulator. It gets inside the regulator through the filter and orifice and collapses the aneroid. This pulls the isobaric metering valve off seat and vents both control head chambers to the atmosphere. Now the pressure on the outside pushes up on the outflow valve diaphragm and lifts the outflow valve off seat. This lets cabin pressure be dumped and the plane is unpressurized.

2. Aircraft starts to climb - All components of the regulator are in the same position as when the aircraft was on the ground. Keep in mind that both control head chambers are vented to the atmosphere. Atmospheric pressure is decreasing as the aircraft climbs.

Answer the statements as true (T) or false (F).

1. At this time the aneroid is compressed.

2. The isobaric metering valve is off seat.

3. Both control head chambers are vented to the atmosphere through the isobaric metering valve.

4. Cabin pressure is building up on the outside of the regulator faster than it can bleed through the orifice into the control head chamber.

5. The outflow valve is off seat.

6. The cabin is not pressurized while the aircraft is on the ground.

7. As the aircraft starts to climb, atmospheric pressure starts to decrease.

ISOBARIC RANGE

1. Aircraft at 11,000 feet - By the time the aircraft has reached 11,000 feet, the atmospheric pressure has dropped to 9.72 psia (see table 1). Now the spring tension inside the aneroid (10 psia) is greater than the pressure in the control head chamber (9.72 psia). The aneroid expands to close the isobaric metering valve. As soon as the metering valve is closed, the outflow valve goes on seat. This is because the pressure inside the control head chambers overcomes the cabin pressure that had been dumped through the outflow valve. Once the outflow valve goes on seat, cabin pressure will build up and bleed through the orifice. This will compress the aneroid (10 psia) and open the metering valve again.

2. Aircraft between 11,000 and 29,000 feet - Between these two heights the regulator keeps cycling (opening and closing). This keeps cabin pressure at 9.72 psia which is equal to the atmospheric pressure at 11,000 feet. This is called "cabin altitude." Cabin altitude means that the plane can fly at any height between 11,000 and 29,000 feet but cabin pressure will stay at the 11,000 ft. value. Keep in mind that all the time the plane is climbing, the pressure on top of the differential diaphragm is decreasing.

Answer the statements as true (T) or false (F).

1. During the isobaric range cabin pressure is at a constant value.

2. Cabin pressure is kept constant by the cycling (opening and closing) of the isobaric metering valve and the outflow valve.

3. While in the isobaric range, "cabin altitude" is equivalent to the atmospheric pressure at one altitude but the aircraft is usually at a higher altitude.

4. The isobaric range is between the point where pressurization begins and the point where the differential section takes over.

CORRECT RESPONSES TO FRAME 22: 1. T 2. T 3. T 4. T 5. T 6. T 7. T

CORRECT RESPONSES TO FRAME 23: 1. T 2. T 3. T 4. T

Frame 24

DIFFERENTIAL RANGE

1. Aircraft at 29,000 feet - When the plane is at 29,000 feet atmospheric pressure on top of the differential diaphragm is down to 4.57 psia. In the control head chamber there is 9.72 psia, that is due to cabin air bleeding through the orifice. The isobaric metering valve can not come off seat since the aneroid has expanded due to its pressure (10 psia) being greater than control head chamber pressure (9.72 psia). The isobaric section is now ineffective so something else is going to have to control cabin pressure.

2. At this time, the differential metering valve is held on seat by 4.57 psia atmospheric pressure plus 5 pounds of spring tension. That makes a total of 9.57 psia. Control head chamber pressure is at 9.72 psia, so, the differential diaphragm is pushed up and pulls the differential metering valve off seat. Air in the control head can vent through the metering valve to the atmosphere. Cabin pressure will push the outflow valve off seat and excessive pressure will be dumped. When atmospheric pressure plus spring tension is greater than the decreasing control head pressure the metering valve will be forced on seat and the cycle starts over. With the differential section in control, cabin pressure will stay at 5 psi more than atmospheric pressure no matter how high the aircraft goes.

Answer the statements as true (T) or false (F).

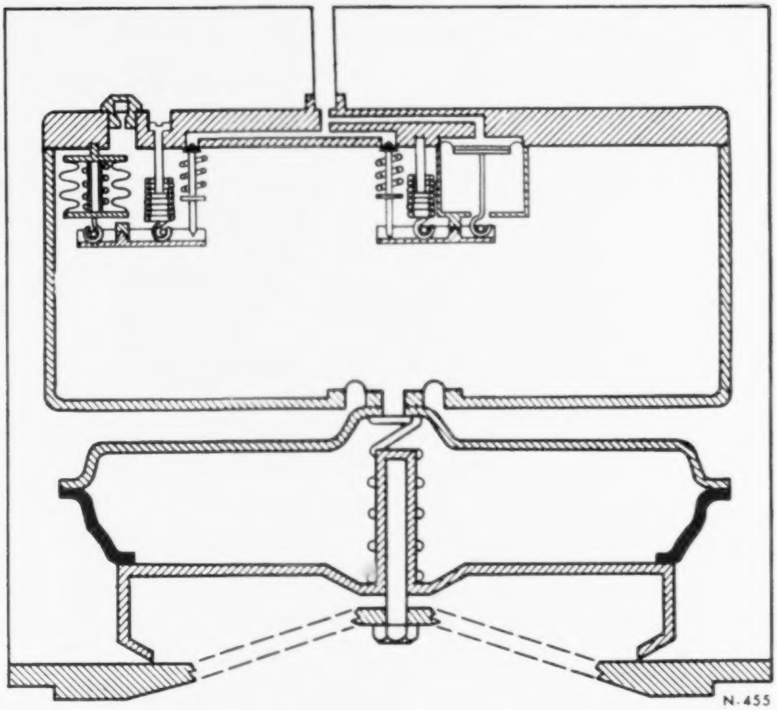
1. The differential section takes over control of pressurization at the point where the isobaric section becomes ineffective.

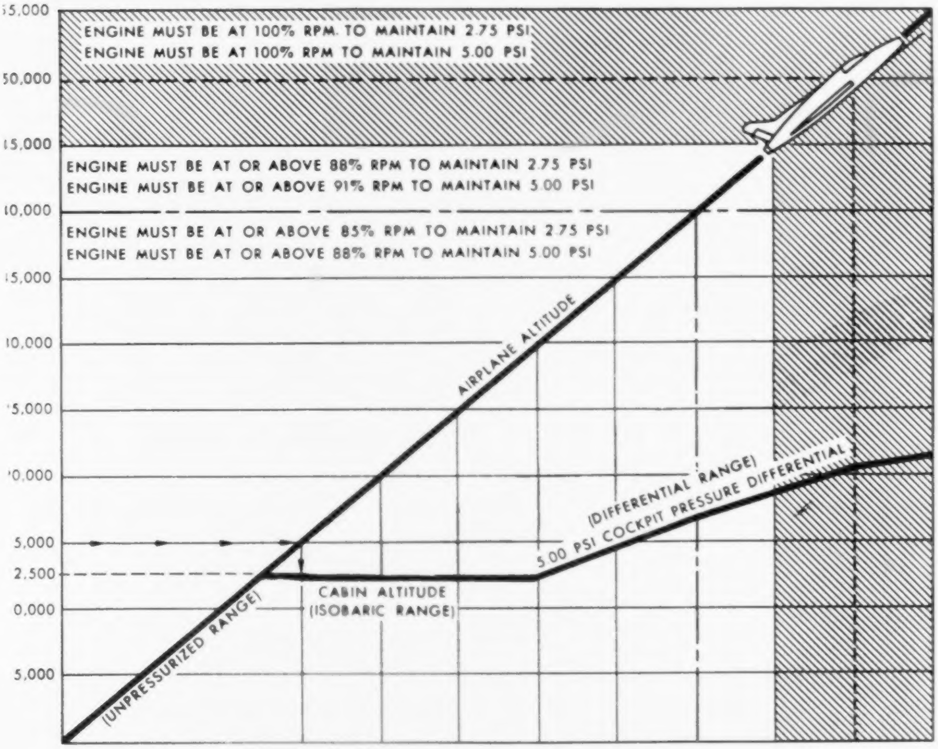
2. Atmospheric pressure plus spring tension tries to hold the differential metering valve on seat.

3. The differential metering valve is forced off seat when control head chamber pressure exceeds atmospheric pressure by 5 psi.

4. The differential section keeps cabin pressure 5 psi greater than atmospheric pressure regardless of aircraft altitude.

CORRECT RESPONSES TO FRAME 24: 1. T 2. T 3. T 4. T


N-455


5,000
50,000
5,000
0,000
5,000
0,000
5,000
0,000
5,000
2,500
0,000
5,000
ENGINE MUST BE AT 100% RPM TO MAINTAIN 2.75 PSI
ENGINE MUST BE AT 100% RPM TO MAINTAIN 5.00 PSI
ENGINE MUST BE AT OR ABOVE 88% RPM TO MAINTAIN 2.75 PSI
ENGINE MUST BE AT OR ABOVE 91% RPM TO MAINTAIN 5.00 PSI
ENGINE MUST BE AT OR ABOVE 85% RPM TO MAINTAIN 2.75 PSI
ENGINE MUST BE AT OR ABOVE 88% RPM TO MAINTAIN 5.00 PSI
AIRPLANE ALTITUDE
(DIFFERENTIAL RANGE)
5.00 PSI COCKPIT PRESSURE DIFFERENTIAL
CABIN ALTITUDE
(ISOBARIC RANGE)
(UNPRESSURIZED RANGE)
N-456

Environmental Pneudraulic Branch
Chanute AFB, Illinois

C3ABR42331-HO-315
1 July 1982

TROUBLESHOOTING PNEUMATIC CONTROL CIRCUITS

OBJECTIVE

Specify the procedures used to troubleshoot pneumatic control circuits with a minimum of 80% accuracy.

INTRODUCTION

A very important part of being an Aircraft Environmental Systems mechanic is knowing how to correctly troubleshoot the systems you will be working with on the aircraft. The following information will give a brief introduction to the procedures that are used to troubleshoot pneumatic control circuits. The troubleshooting procedures presented in this handout may be applied to almost all aircraft systems, not just pneumatic control circuits.

When troubleshooting pneumatic control circuits or any system, follow the step-by-step procedures outlined in the applicable technical order (TO) (including cautions, warnings, and safety notes) to insure that the job is done correctly. The TO usually provides a troubleshooting chart (refer to figure 1) that lists the trouble, provides a list of most probable causes, gives the method for isolating the trouble, and recommends a remedy to correct the trouble.

Before starting the troubleshooting procedures, it is important for the mechanic to read the flight crew write-ups to find out which systems on the aircraft are malfunctioning. Basically, there are seven different procedures to be followed during troubleshooting. They are as follows:

STEP 1: Conduct a visual inspection of the malfunctioning system. This inspection should be a thorough and searching check of the components of the system involved, using the applicable aircraft TO.

STEP 2: Conduct an operational check. The malfunctioning system is checked for proper operation by following the step-by-step procedures in the applicable TO.

STEP 3: Classify the trouble. Try to classify the trouble as being electrical, mechanical, or improper maintenance.

STEP 4: Isolate the trouble. This step calls for sound reasoning and a knowledge of how each component in the system should operate. Use system TOs and schematics to isolate the cause of the malfunction to one or two areas or components.

STEP 5: Locate the trouble. Once the trouble is isolated to a specific area or component, it is fairly easy to find the exact cause of the malfunction.

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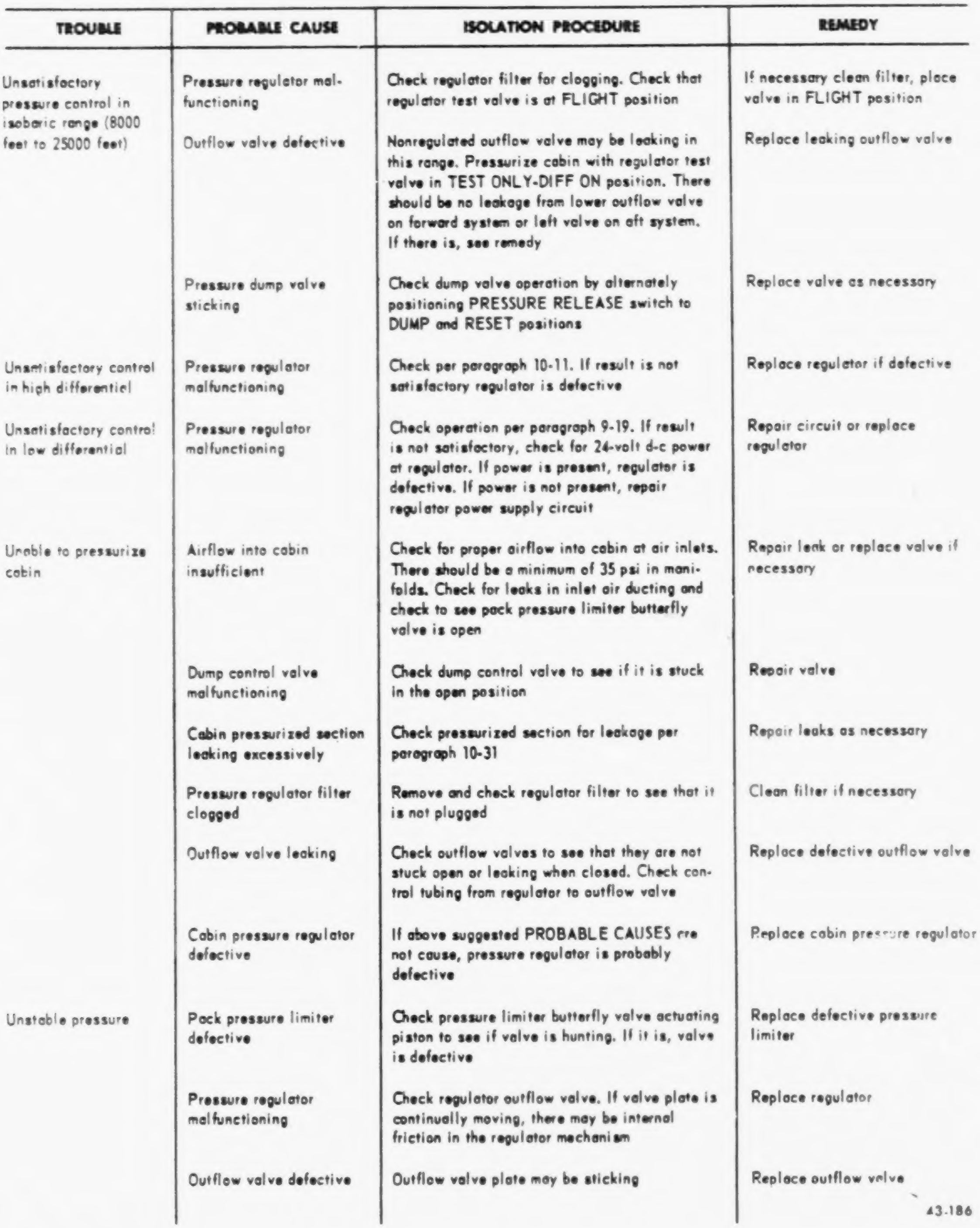
3370 TCHTG/TTGU-P - 500; DAV - 1
Designed for ATC Course Use. Do Not Use on the Job.

RGL: N/A

STEP 6: Correct the trouble. After the problem is definitely identified, the component is removed and replaced or repaired according to the instructions in the TO.

STEP 7: Conduct a final operational check. The affected system must be given an operational check after repairs to verify proper operation. This operational check is again performed by following the step-by-step procedures in the TO.

While troubleshooting pneumatic control circuits, it is very important for your safety and the safety of others to follow the special instructions and notes that are in the TO.



TROUBLE	PROBABLE CAUSE	ISOLATION PROCEDURE	REMEDY
Unsatisfactory pressure control in isobaric range (8000 feet to 25000 feet)	Pressure regulator malfunctioning	Check regulator filter for clogging. Check that regulator test valve is at FLIGHT position	If necessary clean filter, place valve in FLIGHT position
	Outflow valve defective	Nonregulated outflow valve may be leaking in this range. Pressurize cabin with regulator test valve in TEST ONLY-DIFF ON position. There should be no leakage from lower outflow valve on forward system or left valve on aft system. If there is, see remedy	Replace leaking outflow valve
	Pressure dump valve sticking	Check dump valve operation by alternately positioning PRESSURE RELEASE switch to DUMP and RESET positions	Replace valve as necessary
Unsatisfactory control in high differential	Pressure regulator malfunctioning	Check per paragraph 10-11. If result is not satisfactory regulator is defective	Replace regulator if defective
Unsatisfactory control in low differential	Pressure regulator malfunctioning	Check operation per paragraph 9-19. If result is not satisfactory, check for 24-volt d-c power at regulator. If power is present, regulator is defective. If power is not present, repair regulator power supply circuit	Repair circuit or replace regulator
Unable to pressurize cabin	Airflow into cabin insufficient	Check for proper airflow into cabin at air inlets. There should be a minimum of 35 psi in manifolds. Check for leaks in inlet air ducting and check to see pack pressure limiter butterfly valve is open	Repair leak or replace valve if necessary
	Dump control valve malfunctioning	Check dump control valve to see if it is stuck in the open position	Repair valve
	Cabin pressurized section leaking excessively	Check pressurized section for leakage per paragraph 10-31	Repair leaks as necessary
	Pressure regulator filter clogged	Remove and check regulator filter to see that it is not plugged	Clean filter if necessary
	Outflow valve leaking	Check outflow valves to see that they are not stuck open or leaking when closed. Check control tubing from regulator to outflow valve	Replace defective outflow valve
	Cabin pressure regulator defective	If above suggested PROBABLE CAUSES are not cause, pressure regulator is probably defective	Replace cabin pressure regulator
Unstable pressure	Pack pressure limiter defective	Check pressure limiter butterfly valve actuating piston to see if valve is hunting. If it is, valve is defective	Replace defective pressure limiter
	Pressure regulator malfunctioning	Check regulator outflow valve. If valve plate is continually moving, there may be internal friction in the regulator mechanism	Replace regulator
	Outflow valve defective	Outflow valve plate may be sticking	Replace outflow valve

43-186

Figure 1. Typical Pressurization Troubleshooting Chart.

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PROGRAMMED TEXT
C3ABR42331-PT-315A

Technical Training

Aircraft Environmental Systems Mechanic

FIGHTER PRESSURIZATION SYSTEM

22 July 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

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DO NOT USE ON THE JOB

RGL: 9.6

OBJECTIVE

Relate the components of cabin pressurization systems to their operations with 80% accuracy.

INSTRUCTIONS

This package presents information in steps called "frames." After each step you are asked to choose a correct response by matching or telling if a statement is true (T) from a list of statements. Do not mark in the text. Use the reference sheet. Read each frame carefully and then select your answer. The correct answers will be found on the top of the next page. If you are right, proceed to the next frame. If you are wrong or in doubt, read the frame again.

Supersedes 3ABR42331-PT-315A, 12 March 1981.
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Frame 1

The main reason for cabin pressurization is to make the air crew comfortable, while the aircraft is flying at high altitudes. The pressurization system is used to keep a differential pressure between the inside and outside of an aircraft. Most fighter aircraft pressurization systems have a pneumatic dump valve, a cabin pressure safety valve, a cabin pressure regulator, and an emergency vent handle.

Select the phrases that will complete the statement. Indicate your choice as true (T) or false (F).

A pressurization system provides crew comfort by

1. keeping a differential pressure between the inside and the outside of an aircraft.

2. keeping a constant pressure in the cabin regardless of altitude.

3. keeping cabin pressure at 14.7 psia.

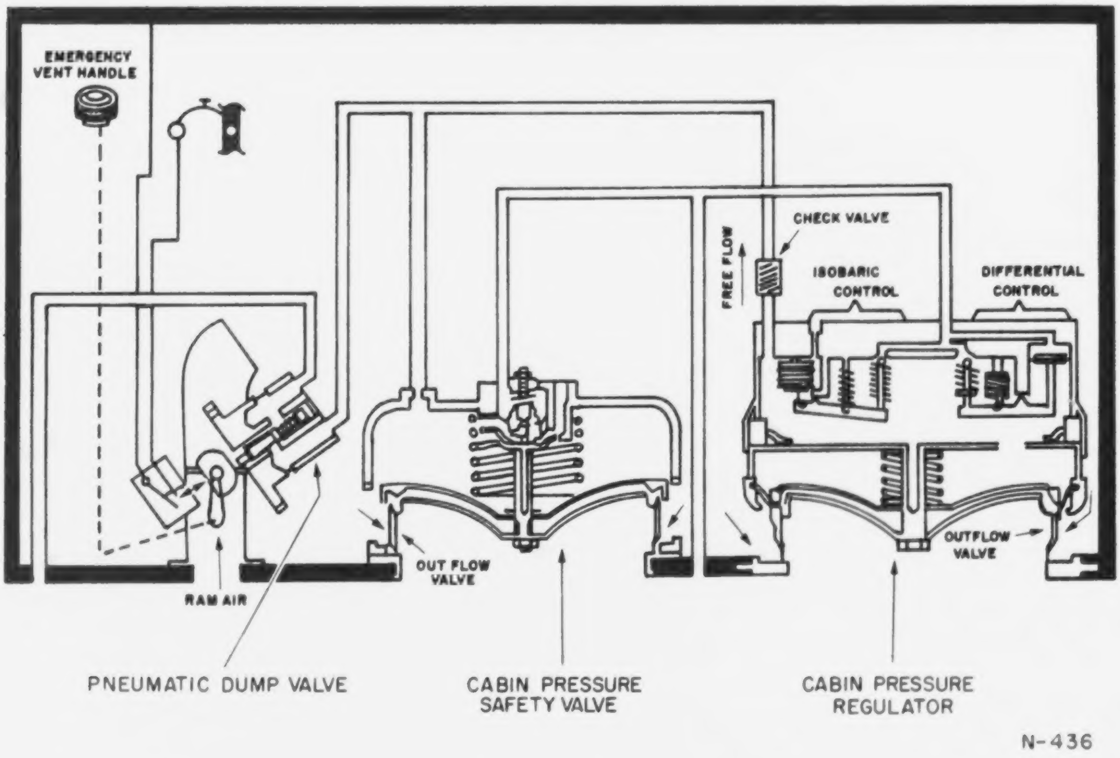

EMERGENCY VENT HANDLE
CHECK VALVE
FREE FLOW
ISOBARIC CONTROL
DIFFERENTIAL CONTROL
OUT FLOW VALVE
OUTFLOW VALVE
RAM AIR
PNEUMATIC DUMP VALVE
CABIN PRESSURE SAFETY VALVE
CABIN PRESSURE REGULATOR
N-436

Diagram 1.

CORRECT RESPONSES TO FRAME 1: 1. T 2. F 3. F

Frame 2

The pressurization system is used to keep the cabin at a desired pressure, when the aircraft is flying. Pressure in the cabin is held in the proper range by controlling the amount of conditioned air that leaves the pressurized cabin.

Select the phrases that will complete the statement. Indicate your choice as true (T) or false (F).

A pressurization system controls the amount of

1. conditioned air flowing into the cabin.
2. ram air entering the cabin.
3. ram air leaving the aircraft.
4. conditioned air leaving the cabin.

CORRECT RESPONSES TO FRAME 2: 1. F 2. F 3. F 4. T

Frame 3

Illustrated is a cabin pressure regulator. This regulator is a fixed (can not be adjusted) isobaric single differential (5.0 psid) type. The text that you studied before this text gave information on this type of regulator.

This regulator has an unpressurized range, an isobaric range, and a differential range of pressurization. This type of air pressure regulator is used on some fighter aircraft.

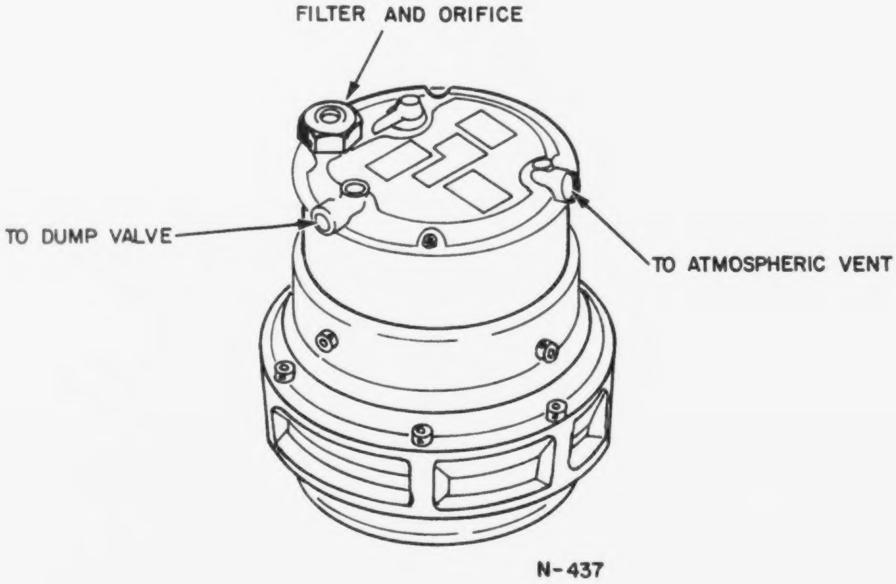


Diagram 2.

Answer the statements as true (T) or false (F).

1. The fighter aircraft pressure regulator has a normal and combat differential setting.

2. The three ranges of pressurization are unpressurized, isobaric, and differential.

3. The fighter aircraft has a fixed isobaric, single differential type of pressure regulator.

CORRECT RESPONSES TO FRAME 3: 1. F 2. T 3. T

Frame 4

The illustration shows the inside of the regulator. You must keep in mind the isoabaric section is used to control the first two ranges of pressurization. Also, the differential section is used to control the third range. The third range will keep a difference of 5.0 psid between cabin pressure and atmospheric pressure. The three ranges are: sea level to 8,000 feet (unpressurized), 8,000 feet to 24,000 feet (isobaric), and 24,000 feet on up (differential).

This type of cabin air pressure regulator has the outflow valve attached to it as shown in the illustration. The amount of air that will leave the pressurized area is controlled by opening and closing the outflow valve.

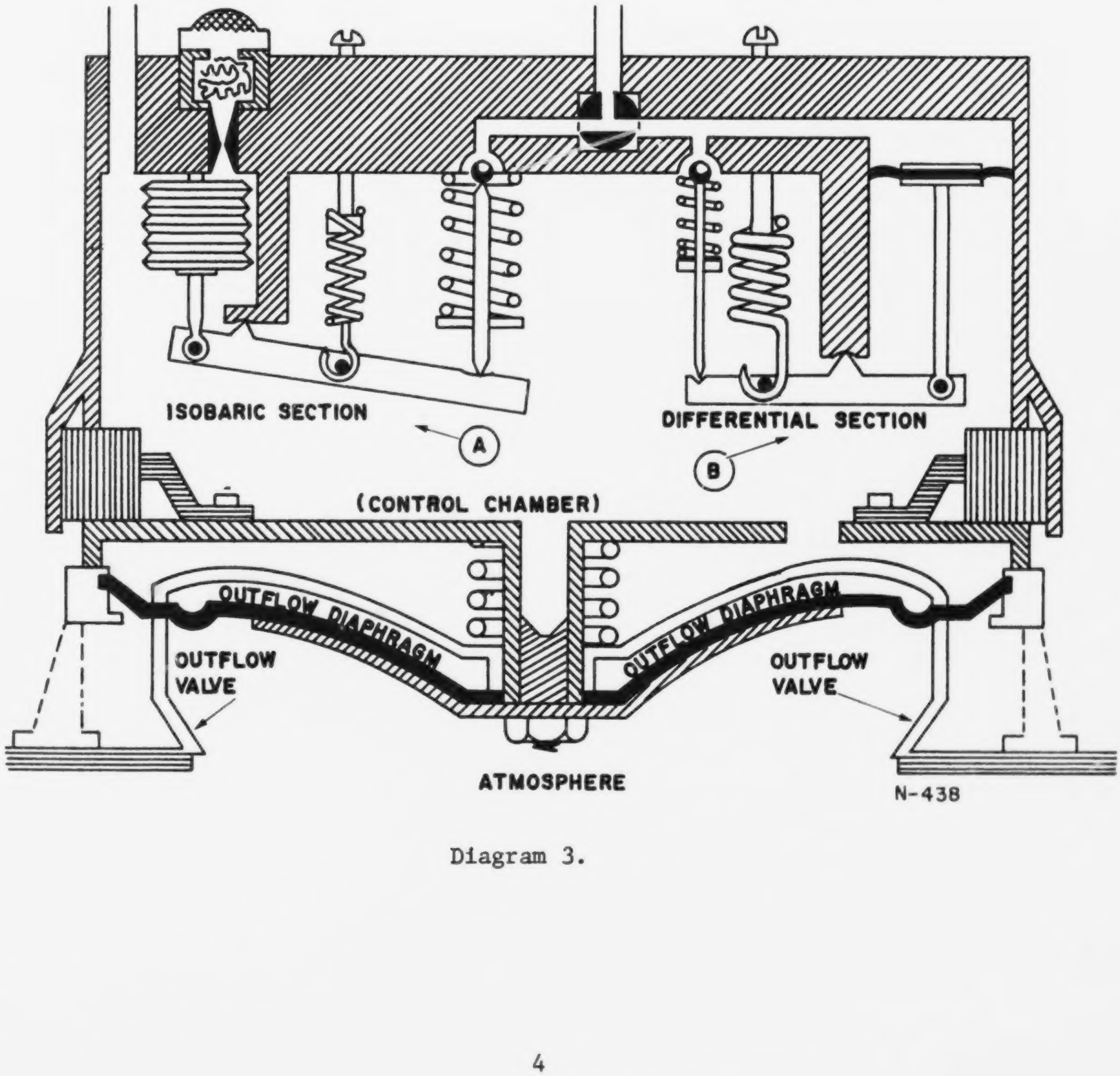

ISOBARIC SECTION
A
DIFFERENTIAL SECTION
B
(CONTROL CHAMBER)
OUTFLOW DIAPHRAGM
OUTFLOW DIAPHRAGM
OUTFLOW DIAPHRAGM
OUTFLOW DIAPHRAGM
OUTFLOW VALVE
OUTFLOW VALVE
ATMOSPHERE
N-438

Diagram 3.

Match the letters in the illustration with the functions listed below.

1. Keeps cabin unpressurized between sea level and 8,000 feet.

2. Keeps a 5.0 psid between the cabin and atmospheric pressures.

3. Keeps an 8,000 feet cabin altitude pressure between aircraft altitudes of 8,000 feet and 24,000 feet.

Answer the statements true (T) or false (F).

4. The outflow valve is attached to the pressure regulator.

5. The outflow valve regulates the amount of air entering the pressurized area.

6. The outflow valve remains closed during the isobaric range.

CORRECT RESPONSES TO FRAME 4: 1. A 2. B 3. A 4. T

5. F 6. F

Frame 5

Look at the diagram as we go through the operation of the regulator. This frame will give operation of one range of the isobaric section. Operation of the unpressurized range will be given in this frame.

The aneroid, shown in the diagram, is a sealed unit that has a set (fixed) pressure. Cabin pressure goes in the control chamber through the filter and orifice assembly. At this point pressure starts to build up. NOTE: From now on the pressure in the control chamber will be called "reference pressure." As REFERENCE PRESSURE builds up, the aneroid starts to collapse. The aneroid collapses because reference pressure on the outside of the aneroid is more than the pressure on the inside. As the aneroid collapses it opens the needle valve. With the needle valve open, air can flow to the atmosphere and cause a drop in reference pressure. The drop in pressure is caused by the rate of air flow through the orifice and open needle valve. The needle valve opening is larger than the orifice opening. Cabin pressure will now force the outflow valve open. With the outflow valve open, cabin air will vent to the atmosphere. The aircraft is now in the UNPRESSURIZED RANGE (sea level to 8,000 feet).

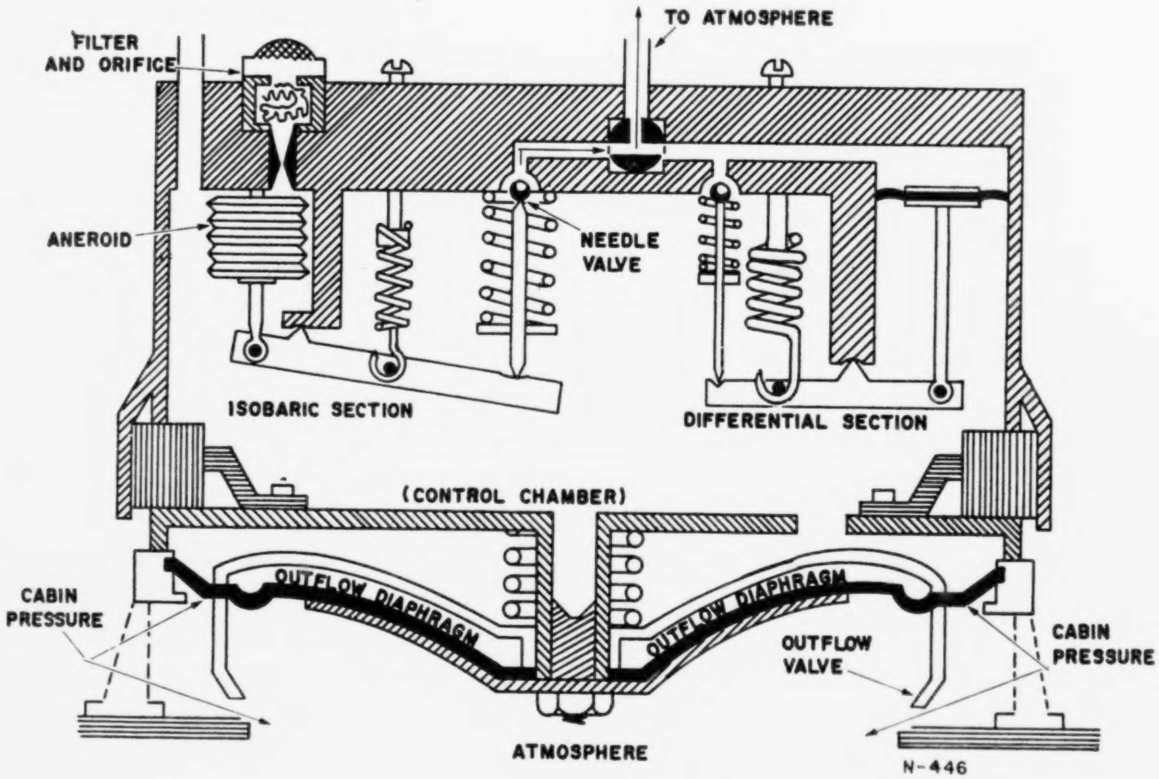

TO ATMOSPHERE
FILTER AND ORIFICE
ANEROID
NEEDLE VALVE
ISOBARIC SECTION
DIFFERENTIAL SECTION
(CONTROL CHAMBER)
OUTFLOW DIAPHRAGM
OUTFLOW DIAPHRAGM
CABIN PRESSURE
OUTFLOW VALVE
CABIN PRESSURE
ATMOSPHERE
N-446

Diagram 4.

Answer the statements as true (T) or false (F).

1. The aneroid has a set (fixed) pressure.

2. The aneroid will collapse when reference pressure is greater than aneroid pressure.

3. Reference pressure cannot vent to the atmosphere as fast as it enters the control chamber.

4. Cabin pressure will open the outflow valve when reference pressure is vented to the atmosphere.

5. With the outflow valve always open, the aircraft is in the unpressurized range.

CORRECT RESPONSES TO FRAME 5: 1. T 2. T 3. F 4. T

5. T

Frame 6

In Frame 5, the aircraft was in the unpressurized range. As the aircraft gains in altitude, the isobaric range will start to operate.

As the aircraft reaches and goes through an altitude of 8,000 feet, the pressure in the control chamber starts to drop. This drop in pressure is caused by the needle valve, for it is off seat (see Frame 5). As reference pressure drops, the aneroid will start to expand and cause the needle valve to close. With the needle valve closed, reference pressure starts to build up. Reference pressure will press down on the outflow valve diaphragm. This pressure, with the aid of the spring, will close the outflow valve (see Frame 5). With the outflow valve closed, cabin air will not continue to vent overboard to the atmosphere. Now pressure will build up in the cabin area. The isobaric section is set to keep the cabin at a pressure that does not change. The pressure is set to be the same as the atmospheric pressure at 8,000 feet of altitude. This reference pressure will be the same up to 24,000 feet of altitude. If reference pressure gets too high, the aneroid starts to collapse. As the aneroid collapses, it will cause the needle valve to open. Air in the control chamber can then vent to the atmosphere; reference pressure will drop. The cabin is kept at the desired pressure by the outflow valve, as it opens and closes. The pressurization system is now operating in the ISOBARIC RANGE (8,000 feet to 24,000 feet).

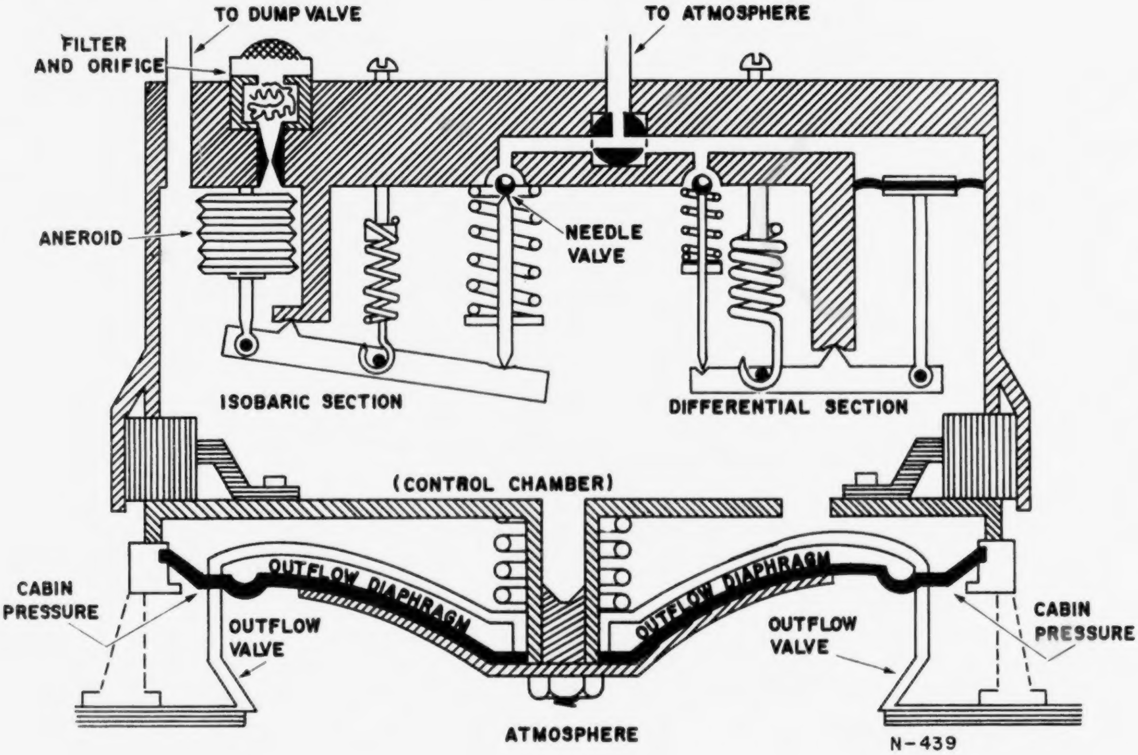

TO DUMP VALVE
TO ATMOSPHERE
FILTER AND ORIFICE
ANEROID
NEEDLE VALVE
ISOBARIC SECTION
DIFFERENTIAL SECTION
(CONTROL CHAMBER)
OUTFLOW DIAPHRAGM
OUTFLOW DIAPHRAGM
CABIN PRESSURE
OUTFLOW VALVE
OUTFLOW VALVE
CABIN PRESSURE
ATMOSPHERE
N-439

Diagram 5.

Answer the statements as true (T) or false (F).

1. At altitudes over 8,000 feet the aneroid will begin to close the needle valve.

2. With the isobaric needle valve closed, reference pressure will vent to the atmosphere.

3. As reference pressure builds up it will force the outflow valve closed.

4. When the outflow valve begins to close, cabin pressure will begin to build up.

5. If a certain constant isobaric pressure is exceeded, the aneroid will begin to collapse and again vent reference pressure to the atmosphere.

CORRECT RESPONSES TO FRAME 6: 1. T 2. F 3. T 4. T

5. T

Frame 7

We have gone through operation of the unpressurized range and the isobaric range. Let us now see how the differential range works.

Look at the diagram; you will note that on one side of the differential diaphragm is atmospheric pressure. On the other side of the diaphragm is reference pressure. The differential spring is set so that it can keep a 5.0 psi difference in pressure between the cabin and atmosphere.

As the aircraft gains in altitude, atmospheric pressure continues to drop. At 24,000 feet atmospheric pressure is 5.70 psia. This pressure plus the 5.0 psid of differential spring tension, makes a total of 10.70 psia. The pressure of 10.70 psia is the pressure that will hold the differential pressure needle valve ON SEAT. When in the isobaric range, reference pressure was kept at 10.91 psia. This setting was held by operation of the aneroid. At this time, 10.91 psia is more than 10.70 psia, so the differential diaphragm is forced up. The diaphragm pulls the differential needle valve OFF SEAT. As air in the control chamber vents to the atmosphere, through the differential needle valve, the aneroid will expand. As the aneroid expands, it will push the isobaric needle valve ON SEAT. This cuts the isobaric section out of the system. Now that reference pressure has dropped, cabin pressure will build and push the outflow valve OFF SEAT. Air in the cabin can now vent to the atmosphere. As the cabin and reference pressures drop, the differential spring pulls the differential needle valve back ON SEAT. This will start the whole process again. This is how the regulator works in the DIFFERENTIAL RANGE (24,000 feet on up).

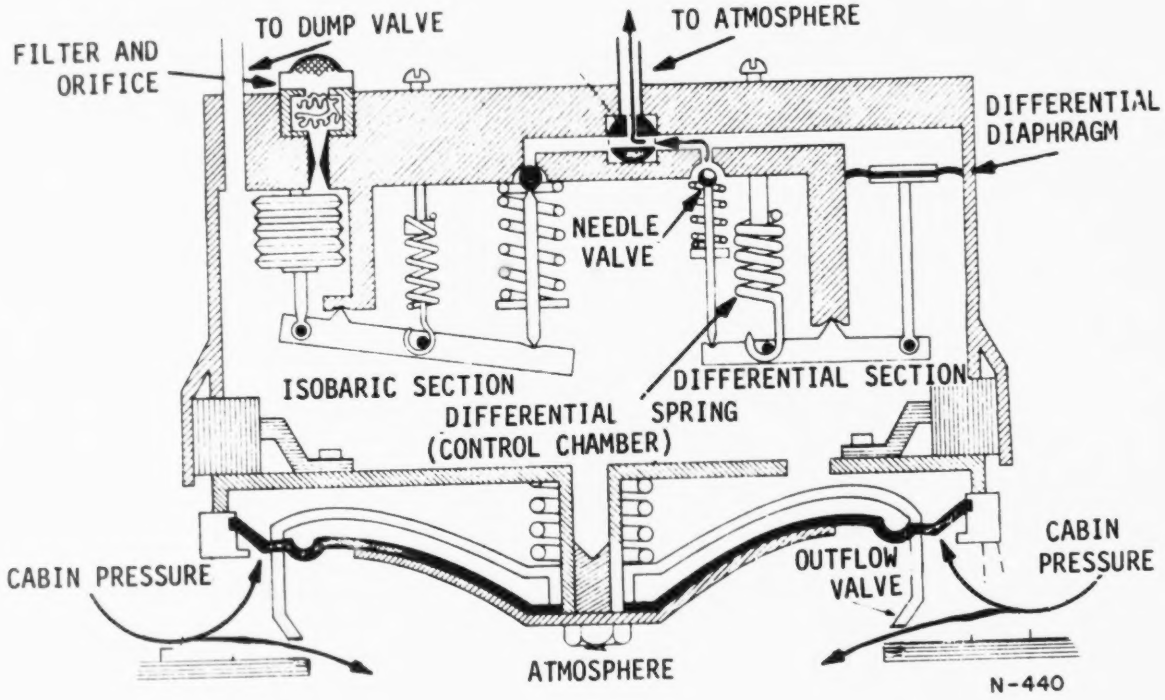

TO DUMP VALVE
FILTER AND ORIFICE
TO ATMOSPHERE
DIFFERENTIAL DIAPHRAGM
NEEDLE VALVE
ISOBARIC SECTION
DIFFERENTIAL SECTION
DIFFERENTIAL SPRING
(CONTROL CHAMBER)
CABIN PRESSURE
OUTFLOW VALVE
CABIN PRESSURE
ATMOSPHERE
N-440

Diagram 6.

Answer the statements as true (T) or false (F).

1. The differential section of the pressure regulator stops operating above 24,000 feet.

2. Above 24,000 feet the isobaric needle valve will be fully closed.

3. The differential diaphragm has atmospheric pressure on one side and reference pressure on the other side.

4. If reference pressure reaches 5.2 psia greater than atmospheric pressure, the differential needle valve will open.

5. If reference pressure decreases, the outflow valve will open.

CORRECT RESPONSES TO FRAME 7: 1. F 2. T 3. T 4. T

5. T

Frame 8

Using the diagram, identify the parts of the regulator.

1. Outflow valve.

2. Isobaric section.

3. Differential section.

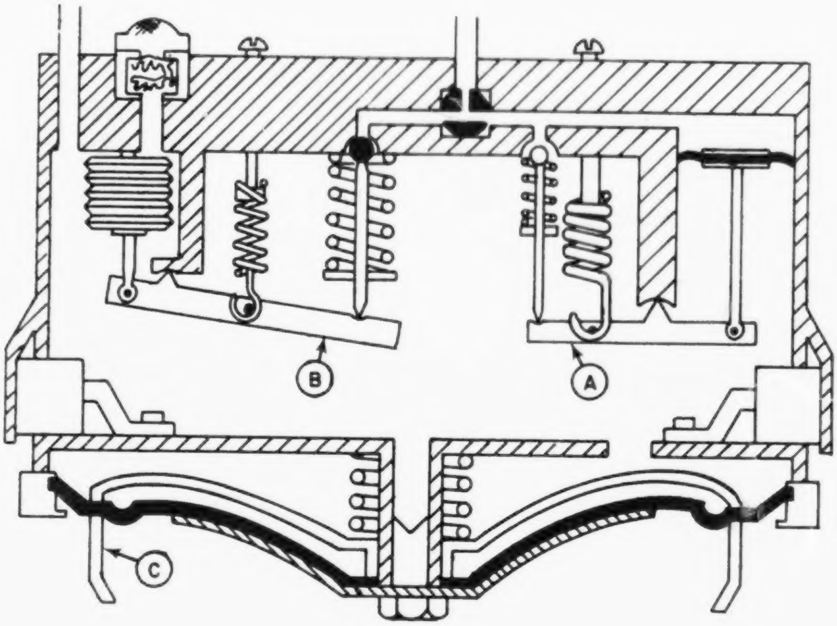


Diagram 7.

1081

CORRECT RESPONSES TO FRAME 8: 1. C 2. B 3. A

Frame 9

REVIEW QUIZ

Answer the statements as true (T) or false (F).

1. A pressurization system provides crew comfort by keeping a predetermined differential pressure in the cabin.

2. A pressurization system controls the amount of air leaving the aircraft cabin.

3. The cabin pressure regulator used on a fighter aircraft is a fixed isobaric, dual differential regulator.

4. The cabin pressure regulator provides three ranges of pressurization.

5. The unpressurized range is from sea level to 8,000 feet.

6. The differential range is from 8,000 feet to 24,000 feet.

7. The outflow valve is attached to the cabin pressure regulator.

8. The isobaric range is from 8,000 feet to 24,000 feet.

9. Cabin pressure will open the outflow valve when reference pressure is vented to the atmosphere.

10. An aneroid controls the isobaric section of the pressure regulator.

11. The differential diaphragm controls the differential section of the pressure regulator.

12. The differential range keeps a 6 psid between cabin pressure and atmospheric pressure.

CORRECT RESPONSES TO FRAME 9: 1. T 2. T 3. F 4. T

5. T 6. F 7. T 8. T

9. T 10. T 11. T 12. F

Frame 10

Now you know how the cabin air pressure regulator works. Let us see what would take place if it did not work. What would keep cabin pressure from becoming so high that the windshield might be popped out, or the canopy might be blown off? You are right -- a safety valve is needed. On some aircraft this valve is called the cabin pressure safety valve.

The safety valve, as you can see in the diagram, looks a lot like an outflow valve. The safety valve is put on the aircraft in the same way as the outflow valve.

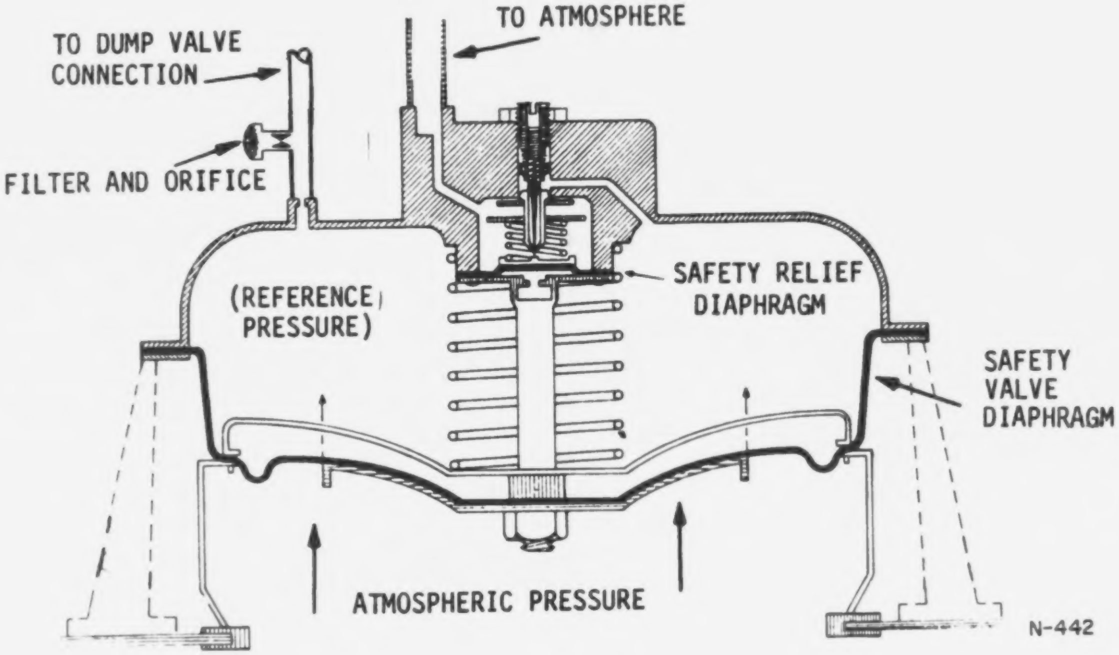

TO ATMOSPHERE
TO DUMP VALVE CONNECTION
FILTER AND ORIFICE
(REFERENCE PRESSURE)
SAFETY RELIEF DIAPHRAGM
SAFETY VALVE DIAPHRAGM
ATMOSPHERIC PRESSURE
N-442

Diagram 8.

Answer the statements as true (T) or false (F).

1. The safety valve relieves cabin pressure if the regulator should fail.

2. The safety valve is mounted on the aircraft in the same way that an outflow valve is mounted.

3. The safety valve is attached directly to the cabin pressure regulator.

CORRECT RESPONSES TO FRAME 10: 1. T 2. T 3. F

Frame 11

The cabin pressure safety valve can do these three functions: (1) The valve will dump cabin pressure at 5.25 psid, if the regulator failed to work. (2) It does not allow a negative cabin pressure (vacuum). Negative pressure is when atmospheric pressure is more than cabin pressure. (3) It helps to dump pressure when the cabin needs to be depressurized fast.

Cabin air flows into the safety valve through the filter and orifice assembly. Once cabin air is in the valve, the air is called REFERENCE PRESSURE. This reference pressure will build up and push down on the safety valve diaphragm and up on the safety relief diaphragm. Air tries to flow through the top passageway, on the right side, but is blocked by the needle valve that is now ON SEAT.

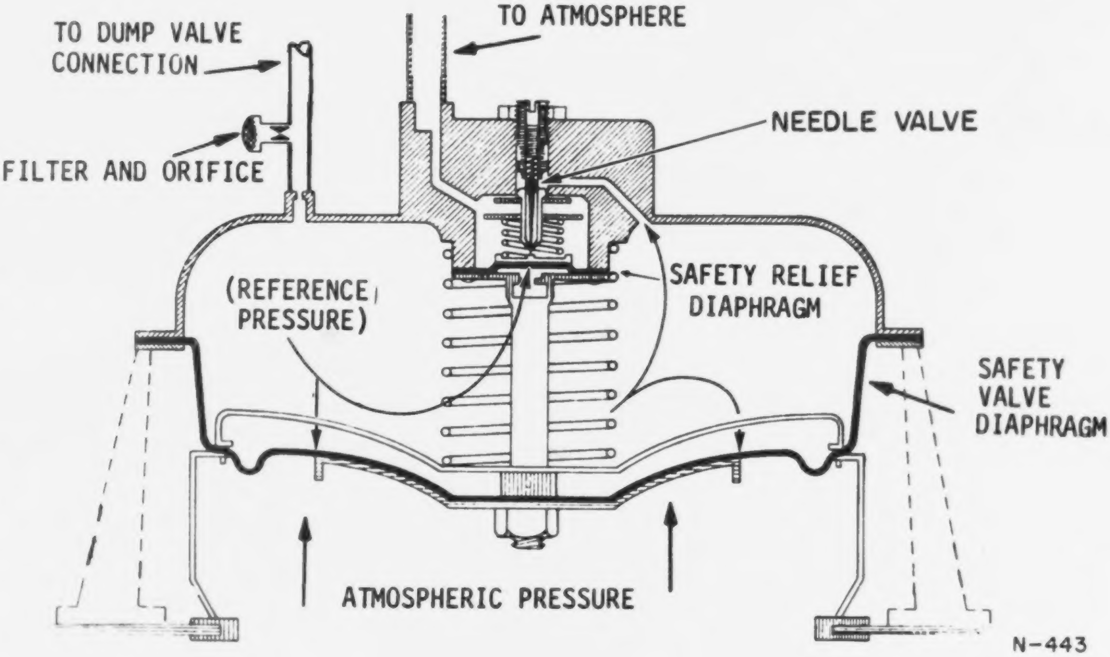

TO DUMP VALVE CONNECTION
TO ATMOSPHERE
NEEDLE VALVE
FILTER AND ORIFICE
(REFERENCE PRESSURE)
SAFETY RELIEF DIAPHRAGM
SAFETY VALVE DIAPHRAGM
ATMOSPHERIC PRESSURE
N-443

Diagram 9.

Answer the statements as true (T) or false (F).

1. The cabin pressure safety valve performs three functions.
2. Cabin pressure and reference pressure will be at the same value.
3. The needle valve is held ON SEAT by spring tension.
4. Cabin air flowing into the safety valve is not restricted.

CORRECT RESPONSES TO FRAME 11: 1. T 2. T 3. T 4. F

Frame 12

Let us see what happens if the cabin pressure regulator fails. Keep in mind, atmospheric pressure will press down on the top side of the safety relief diaphragm. Reference pressure will push up on the back side of the diaphragm. When the differential section fails to ease cabin pressure at 5.0 psid, reference pressure in the safety valve builds up until it gets to 5.25 psid. At this time the safety relief diaphragm is pushed up. It in turn will push needle valve up and OFF SEAT. Now air can flow through the top passageway. Air flow is past the needle valve and out the atmospheric vent line. When reference pressure in the safety valve has eased, cabin pressure will push up on the safety diaphragm. Cabin pressure will OFF SEAT the outflow valve. This will allow the high cabin pressure to be eased through the outflow valve to the atmosphere. The safety valve will be fully open at 5.5 psid.

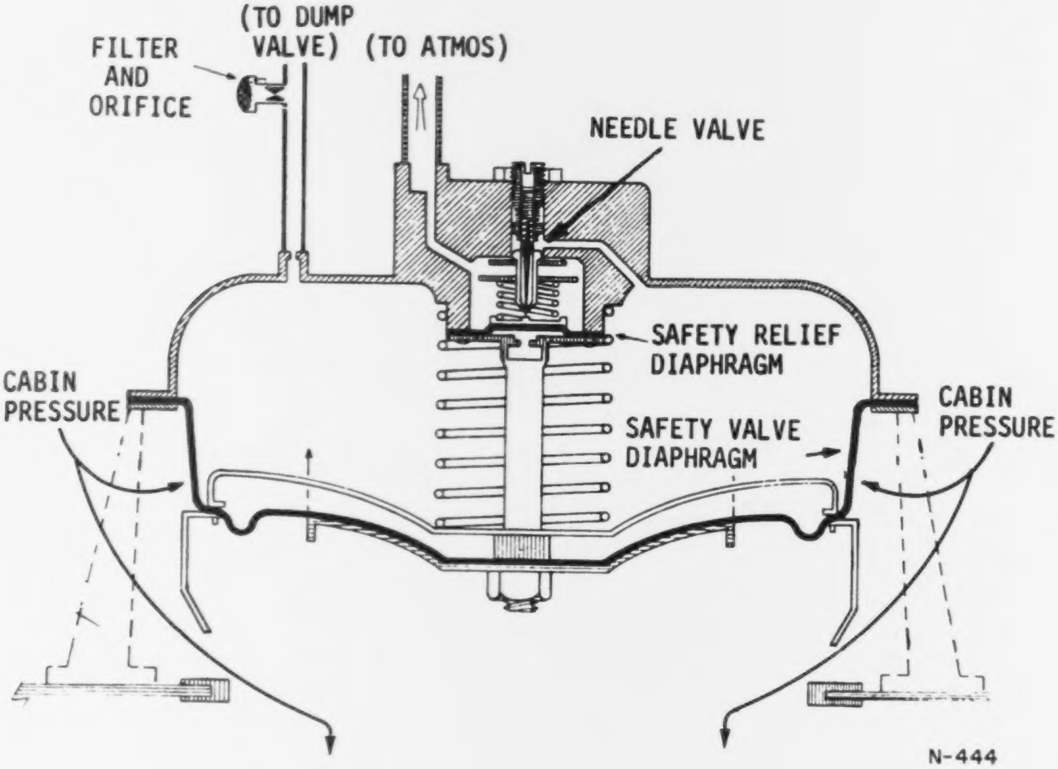

(TO DUMP VALVE)
(TO ATMOS)
FILTER AND ORIFICE
NEEDLE VALVE
SAFETY RELIEF DIAPHRAGM
CABIN PRESSURE
SAFETY VALVE DIAPHRAGM
CABIN PRESSURE
N-444

Diagram 10.

Answer the statements as true (T) or false (F).

1. The needle valve is pushed OFF SEAT when the safety relief diaphragm moves up.

2. Cabin pressure pushes the safety valve diaphragm up, lifting the outflow valve OFF SEAT.

CORRECT RESPONSES TO FRAME 12: 1. T 2. T

Frame 13

An aircraft is made to take only the stress force that moves out. If there was a case that would cause a stress force to move in, the aircraft could be crushed and the flight crew hurt. This could be the case when the pilot puts the aircraft in a fast dive. When in a dive atmospheric pressure on the outside of the aircraft is more than cabin pressure inside. This tends to cause a negative pressure (or vacuum) in the cabin. The stress force will then work inward. When this is the case the cabin pressure safety valve does the second job. Atmospheric pressure (which is now more than cabin pressure) will push the safety diaphragm up. This will lift the outflow valve OFF SEAT. Now air from the atmosphere can flow in and build cabin pressure up to the right value. With the inside and outside pressures now in balance, the aircraft will not be damaged.

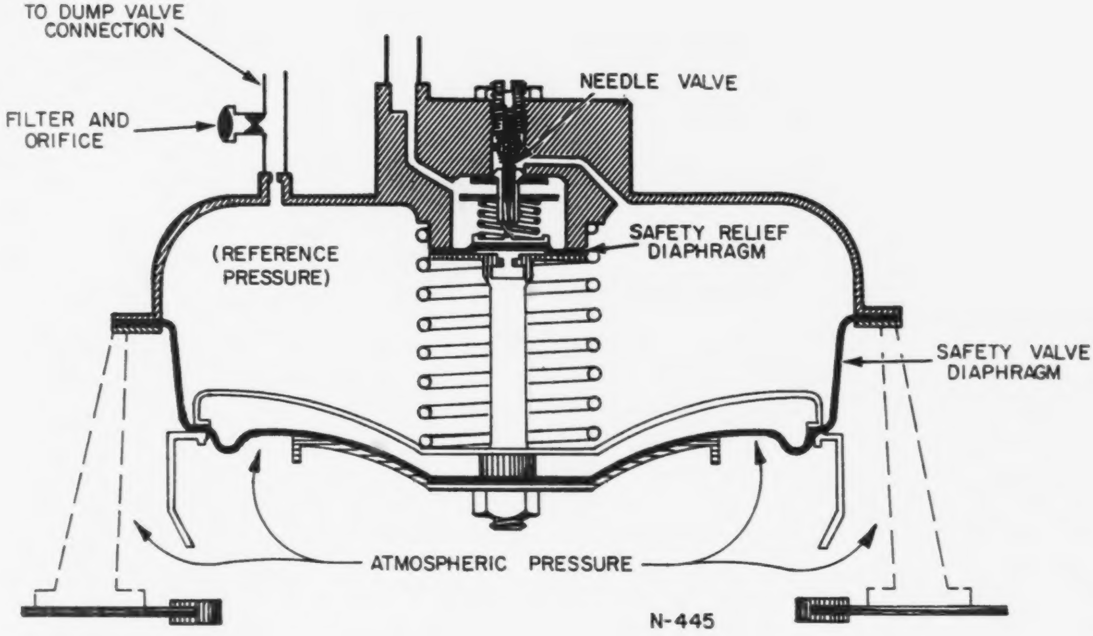

TO DUMP VALVE CONNECTION
FILTER AND ORIFICE
NEEDLE VALVE
(REFERENCE PRESSURE)
SAFETY RELIEF DIAPHRAGM
SAFETY VALVE DIAPHRAGM
ATMOSPHERIC PRESSURE
N-445

Diagram 11.

Answer the statements as true (T) or false (F).

1. The safety valve prevents a negative pressure in the cabin.

2. Under negative pressure conditions the needle valve is OFF SEAT.

3. When the outflow valve is pushed OFF SEAT the atmospheric and cabin pressures will equalize.

4. When the aircraft is in a rapid dive the atmospheric pressure will increase faster than cabin pressure.

CORRECT RESPONSES TO FRAME 13: 1. T 2. F 3. T 4. T

Frame 14

Another function of the cabin pressure safety valve is to help dump cabin pressure when it needs to be dumped. You are now wondering, how does the valve help and when would the cabin need to be depressurized? First, the safety valve helps the cabin pressure regulator to dump cabin pressure. Second, if the cabin is filled with smoke or fuel fumes it will need to be depressurized. If this happens the cabin must be quickly vented to the atmosphere. A supply of ram air is used to force the smoke or fumes overboard.

The whole depressurization phase starts when the pilot pulls the emergency vent control knob. The knob is on the control panel. When the knob is pulled, it mechanically positions the dump valve. The dump valve is shown in the schematic.

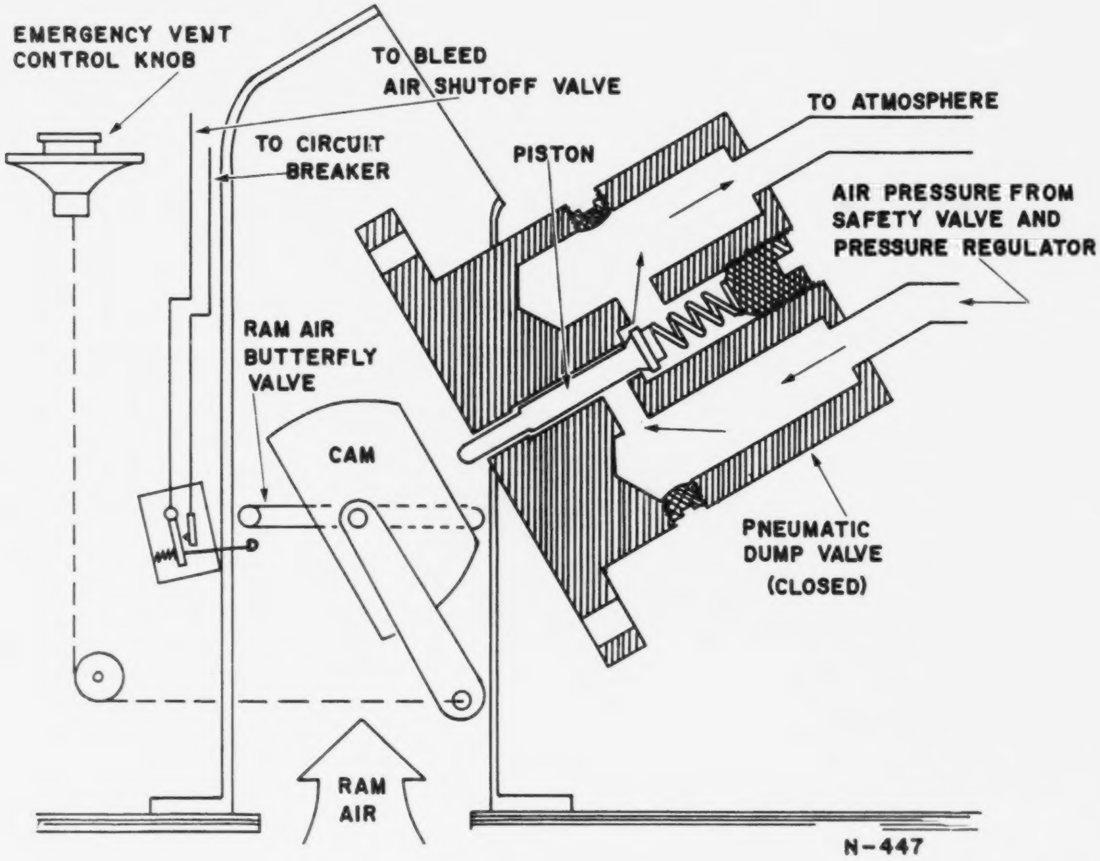

EMERGENCY VENT CONTROL KNOB
TO BLEED AIR SHUTOFF VALVE
TO ATMOSPHERE
TO CIRCUIT BREAKER
PISTON
AIR PRESSURE FROM SAFETY VALVE AND PRESSURE REGULATOR
RAM AIR BUTTERFLY VALVE
CAM
PNEUMATIC DUMP VALVE (CLOSED)
RAM AIR
N-447

Diagram 12.

NO RESPONSE REQUIRED.

CORRECT RESPONSES TO FRAME 14: None Required.

Frame 15

Let us see what happens when the pilot pulls the emergency vent knob. (1) The cam and ram air butterfly valve turns in a clockwise direction. One end of the cam will push the valve up and OFF SEAT. NOTE: Just the butterfly is inside the ram air duct. The cam and lever are located on the outside of the duct. The cam and lever are on the same shaft. (2) Reference pressure from both the safety valve and the cabin pressure regulator is dumped overboard past the valve. (3) Cabin pressure can now push both outflow valves OFF SEAT. Cabin pressure is then dumped overboard. (4) The other end of the cam will touch and open the microswitch. This switch deenergizes the bleed air regulator and shutoff valve assembly (one valve), and this valve then closes. The flow of air that is used to drive the air conditioning system stops. This stops the flow of conditioned air to the cabin. (5) At the same time that the cam moved, the butterfly turned clockwise to the full open position. (6) Ram air can now flow into the cabin. Ram air flows out through the two outflow valves, carrying any smoke or fumes out with it.

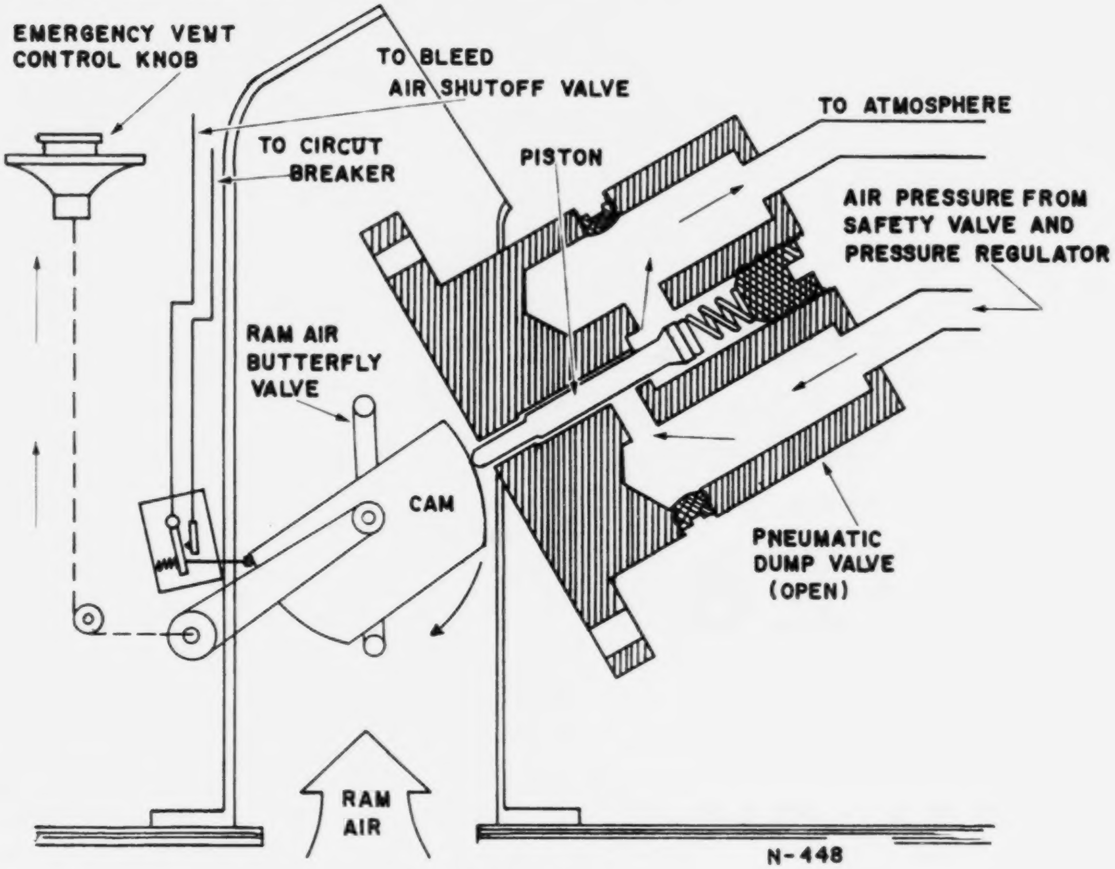

EMERGENCY VENT CONTROL KNOB
TO BLEED AIR SHUTOFF VALVE
TO ATMOSPHERE
TO CIRCUT BREAKER
PISTON
AIR PRESSURE FROM SAFETY VALVE AND PRESSURE REGULATOR
RAM AIR BUTTERFLY VALVE
CAM
PNEUMATIC DUMP VALVE (OPEN)
RAM AIR
N-448

Diagram 13.

Frame 15 (continued)

Below is a list of events that occur during emergency depressurization of the cabin. Number the events according to the order in which they take place.

A. Reference pressures are vented to the atmosphere, the air conditioning system stops, and ram air rushes into the cabin.

B. The pilot pulls the emergency vent control knob.

C. The outflow valves open and dump cabin pressure.

D. The valve is pushed off seat and the microswitch is opened.

E. Ram air flows through the cabin and out through the outflow valves carrying smoke and/or fumes out with it.

F. The cam and butterfly valve rotate in a clockwise direction.

CORRECT RESPONSES TO FRAME 15: A. 4 B. 1 C. 5 D. 3

E. 6 F. 2

Frame 16

Just one item to go and you will be done. Look at the schematic and find the check valve. Note, it is in the line that connects the control chambers of the three valves The line has to be there to allow reference pressure in the regulator to drop, when the dump valve is opened. What does the check valve do? Look at the regulator. Do you know what the orifice does? The orifice keeps the flow of cabin air from entering the control chamber faster than the needle valve can relieve it. Right? If there was no check valve, reference air (pressurized) from the safety valve could flow into the regulator and mix with the air that flows through the orifice. This volume of air would be more than the needle valve could handle. Result: The regulator outflow valve would be held ON SEAT all of the time. The regulator could not properly control cabin pressure.

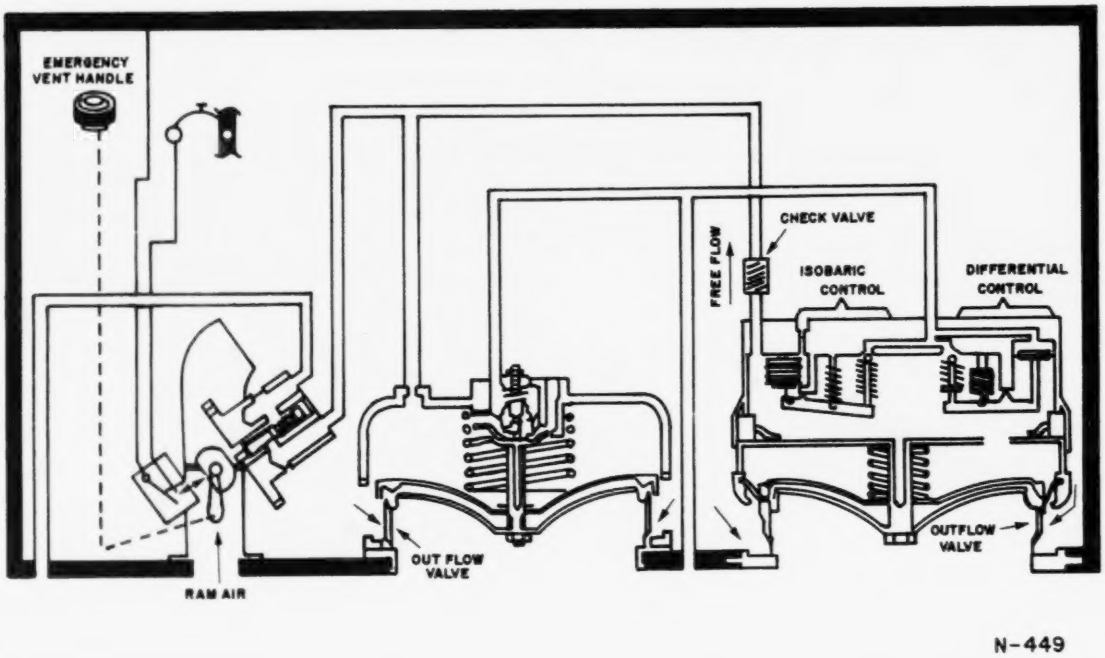

EMERGENCY VENT HANDLE
RAM AIR
OUT FLOW VALVE
FREE FLOW
CHECK VALVE
ISOBARIC CONTROL
DIFFERENTIAL CONTROL
OUTFLOW VALVE
N-449

Diagram 14.

NO RESPONSE REQUIRED.

Frame 17

Answer the following statements as true (T) or false (F).

1. The purpose of a pressurization system is to keep a predetermined pressure in the aircraft cabin. This pressure provides crew comfort and safety.

2. The pressurization system controls the amount of conditioned air entering the cabin.

3. The pressurization system used on a fighter aircraft is a fixed isobaric, dual differential system.

4. One function of the isobaric section is to prevent the cabin from being pressurized between sea level and about 8,000 feet.

5. The three functions of the cabin air safety valve are (1) help dump cabin pressure, (2) relieve excessive cabin pressure if the regulator fails, (3) prevent a negative cabin pressure.

6. The emergency vent knob is pulled to start the safety valve.

7. The check valve installed in the pressurization system prevents regulator reference pressure from escaping to the safety valve.

8. The differential section of the regulator maintains a 5.0 psid between the cabin and atmosphere above 24,000.

9. The isobaric section of the regulator maintains an 8,000 ft. cabin altitude pressure at aircraft altitudes between 8,000 and 24,000 feet.

10. The negative pressure relief function of the safety valve operates when atmospheric pressure is less than reference pressure.

11. One outflow valve is attached directly to the pressure regulator.

12. Both outflow valves open during emergency cabin depressurization.

13. The cabin pressure safety valve is a two function valve.

14. The excessive pressure relief section of the safety valve will be fully open at 5.5 psid.

15. When the pneumatic dump valve is operated, reference pressure is vented from the safety valve to the atmosphere and the safety valve helps dump cabin pressure.

CORRECT RESPONSES TO FRAME 17:

1. T
2. F
3. F
4. T
5. T
6. F
7. F
8. T
9. T
10. F
11. T
12. T
13. F
14. T
15. T

PROGRAMMED TEXT
C3ABR42331-PT-315B

Technical Training

Aircraft Environmental Systems Mechanic

BOMBER PRESSURIZATION SYSTEM

29 July 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

OBJECTIVES

1. Relate the terms associated with the operation of the cabin pressurization system with 80% accuracy.

2. Relate the components of the cabin pressurization system to their operations with 80% accuracy.

INSTRUCTIONS

This program is presented in small steps called "frames." After each frame you are asked to identify the correct statements. You are also asked to match some statements. The correct answers can be found at the top of the page after each frame. If your answer is correct, proceed to the next frame. If your answer is wrong, go back and reread the material before going to the next frame.

Supersedes 3ABR42331-PT-315B, 25 November 1980.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

Frame 1

The schematic is of a B-52 pressurization system. Starting at the upper left of the schematic, the parts are:

Pressure release switch.

Master pressurization switch.

Pressure regulator.

Dump control valve.

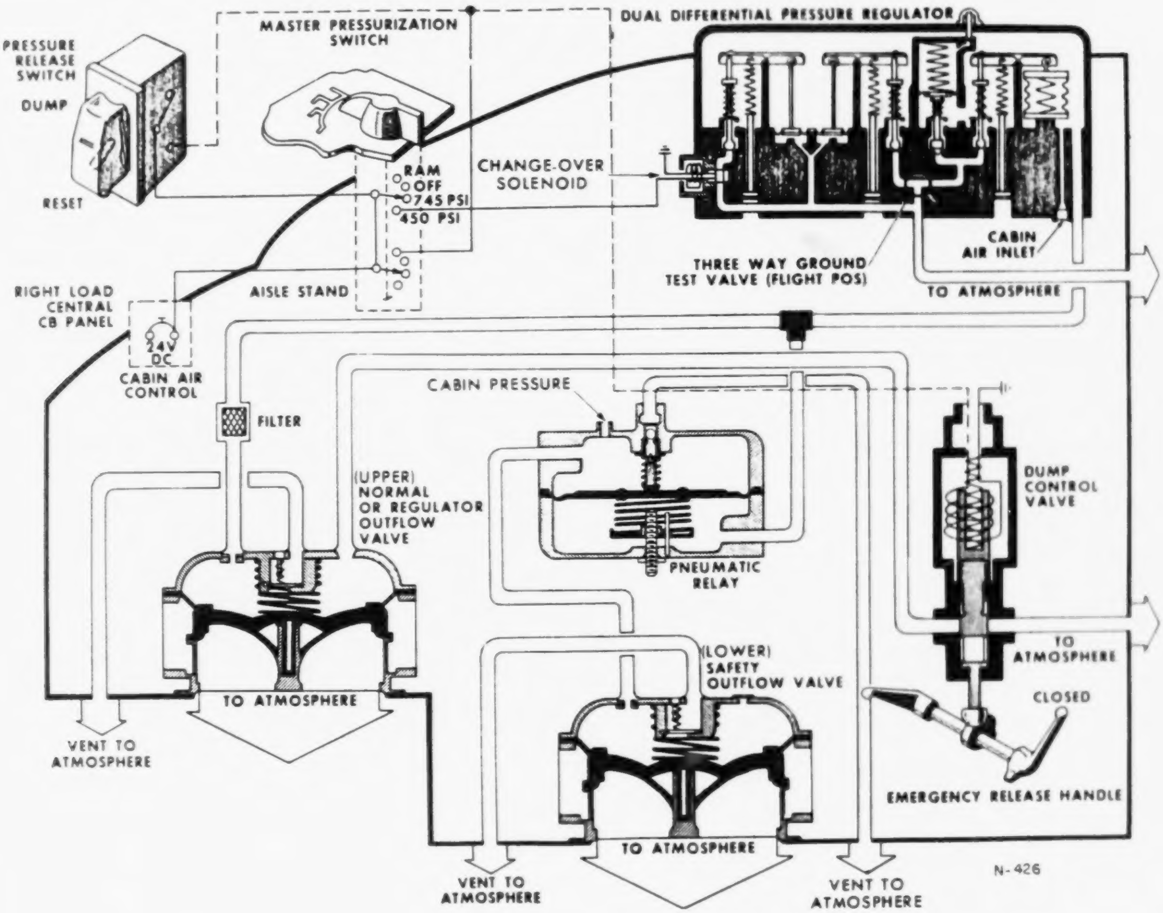
Emergency release handle.

Pneumatic relay.

Safety outflow valve.

Normal outflow valve.

Study the schematic to become familiar with the parts before continuing.


PRESSURE RELEASE SWITCH
DUMP
RESET
MASTER PRESSURIZATION SWITCH
RAM
OFF
7.45 PSI
4.50 PSI
CHANGE-OVER SOLENOID
DUAL DIFFERENTIAL PRESSURE REGULATOR
THREE WAY GROUND TEST VALVE (FLIGHT POS)
CABIN AIR INLET
TO ATMOSPHERE
RIGHT LOAD CENTRAL CB PANEL
AISLE STAND
24V DC
CABIN AIR CONTROL
FILTER
CABIN PRESSURE
(UPPER) NORMAL OR REGULATOR OUTFLOW VALVE
PNEUMATIC RELAY
DUMP CONTROL VALVE
TO ATMOSPHERE
CLOSED
EMERGENCY RELEASE HANDLE
(LOWER) SAFETY OUTFLOW VALVE
TO ATMOSPHERE
VENT TO ATMOSPHERE
TO ATMOSPHERE
VENT TO ATMOSPHERE
VENT TO ATMOSPHERE
N-426

NO RESPONSE REQUIRED

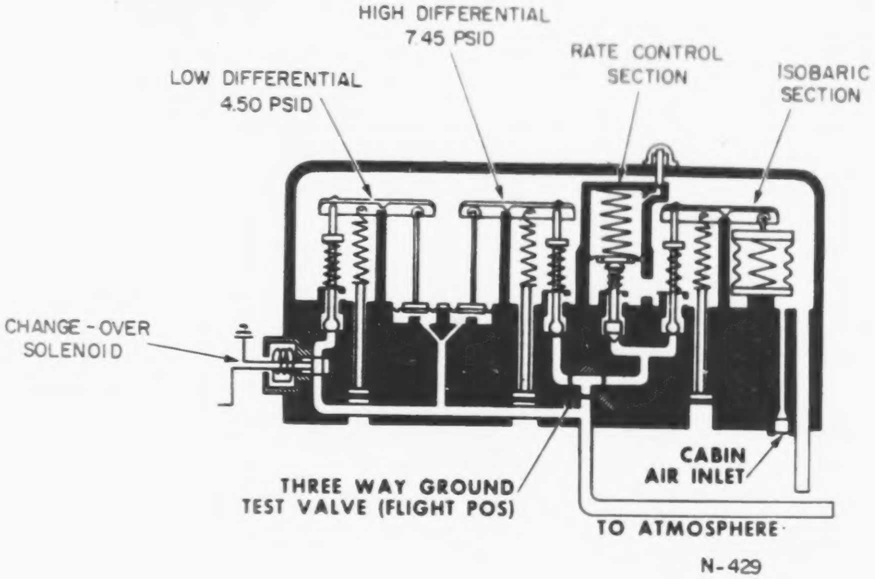
Frame 2

The first part we will discuss is the pressure regulator. It is made up of an isobaric section, two differential sections, a change-over solenoid, a three-way ground test valve, and a rate control section.

The isobaric section works just like the ones you have learned. We will not discuss this one in detail.

The low differential is for use when the plane is in a combat zone. The lower the differential pressure the slower the decompression rate if any enemy bullet rips through the cabin area.

The high differential is used when the plane is out of a combat zone. Note the pressure settings for each of the differential sections.


HIGH DIFFERENTIAL
7.45 PSID
LOW DIFFERENTIAL
4.50 PSID
RATE CONTROL
SECTION
ISOBARIC
SECTION
CHANGE-OVER
SOLENOID
CABIN
AIR INLET
THREE WAY GROUND
TEST VALVE (FLIGHT POS)
TO ATMOSPHERE
N-429

Dual Differential Pressure Regulator.

Answer the statements as true (T) or false (F).

1. The low differential will be used in a combat zone.

2. The isobaric section works just like the one in the F-4C cabin pressure regulator.

3. The high differential will be used when the plane is in a combat zone.

4. The change-over solenoid is part of the low differential section.

Correct Responses to Frame 2: 1. T 2. T 3. F 4. T

Frame 3

The change-over solenoid is in the open position, when the pilot sets the master pressurization switch to the 4.50 (low differential) psid position. The plunger moves to the right, opening the differential to atmosphere. In all other switch positions the solenoid is deenergized, and will close the atmospheric vent line. This will keep the low differential from relieving pressure. The low differential will open the needle valve at 4.50 psid, but nothing will happen since the deenergized solenoid has the vent line closed and head pressure can not be dumped.

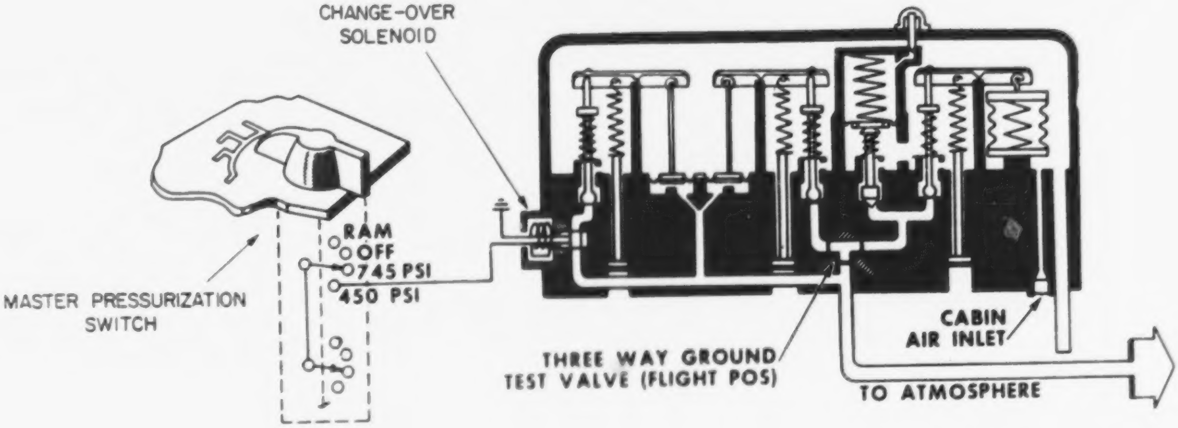
The sole job of the three-way ground test valve is to ground test the cabin pressurization system. Look at the schematic as we discuss the valve. The valve has three positions which are:

1. FLIGHT POSITION - In this position the isobaric, rate control, and high differential sections are all connected to the atmospheric vent line. The regulator can now operate. The three-way valve is safety wired to the flight position.

2. TEST ONLY-DIFFERENTIAL ON POSITION - Think of the valve as if it had been moved 1/4 turn clockwise. This shuts off the rate control and isobaric sections. When pressure is pumped to the regulator, the rate control and isobaric sections do not work for the vent to the atmosphere is blocked. Head pressure will continue to build up. If the change-over solenoid is energized, head pressure will be relieved at 4.50 psid through the low differential. If the solenoid is deenergized, head pressure will climb to 7.45 psid since the low differential will not now work. Keep in mind 7.45 psid is the high differential setting. With the three-way valve to the TEST ONLY-DIFFERENTIAL ON position we can ground test both differential sections for proper operation.

3. TEST ONLY-ALL OFF POSITION - Think of the three-way valve as if it had been moved 1/2 turn clockwise from the position shown. With the change-over solenoid deenergized, all vent lines are blocked and the regulator can not control cabin pressure. This tests operation of the outflow valves (see frame 1) as safety valves. We will have more on the outflow valves later.

Frame 3 (Cont'd)


CHANGE-OVER SOLENOID
MASTER PRESSURIZATION SWITCH
RAM
OFF
745 PSI
450 PSI
THREE WAY GROUND TEST VALVE (FLIGHT POS)
CABIN AIR INLET
TO ATMOSPHERE

N-430

Answer the statements as true (T) or false (F).

1. The change-over solenoid is energized closed.

2. The three-way ground test valve is used to ground test the cabin pressurization system.

3. When the three-way valve is in the flight position, the isobaric section can not work.

4. When the three-way valve is in the test only, differential on position, head pressure will be relieved by one of the differential sections.

5. If the change-over solenoid is closed, the low differential will still work but its operation will be ineffective.

6. The setting of the high differential section is 7.45 psid.

7. If the three-way valve is in the test only, all off position and the change-over solenoid is deenergized, the regulator will not work.

8. The three-way valve is normally safetywired to the test only, differential on position.

9. The setting of the low differential section is 4.50 psid.

10. When the low differential needle valve is off seat, head pressure is vented to the atmosphere through the three-way valve.

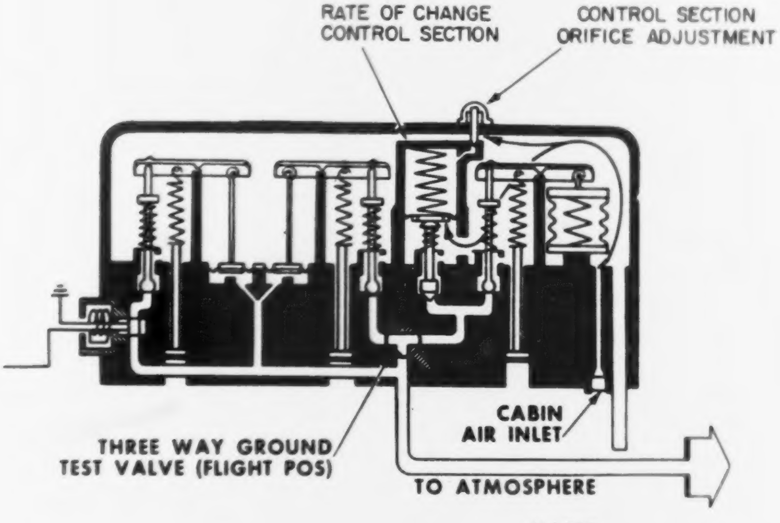
Correct Responses to Frame 3: 1. F 2. T 3. F 4. T
5. T 6. T 7. T 8. F
9. T 10. F

Frame 4

The rate control section protects the flight crew from too fast a rise in pressure. The section keeps the buildup of cabin pressure to 1 psid per minute. Here is when and how it works.

Suppose the master pressurization switch is in the 4.50 psid position. The pilot decides to change the switch to the 7.45 psid position. The change-over solenoid will close. The low differential, that has been controlling cabin pressure, stops. Cabin and head pressures tend to jump to 7.45 psid, the high differential setting. It does not sound like much, but a fast rise in pressure of 3 psid could burst ear drums or damage the plane. Look at the schematic to see how this is prevented by the rate control section.

Notice that as head pressure increases air is free to flow to the bottom of the rate control section. On top, head pressure is restricted by the adjustable orifice. Since head pressure can build up much faster on the bottom than on the top, the rate control section diaphragm moves up. The needle valve is pulled off seat to vent part of the head pressure to the atmosphere. When head pressure on top of the control diaphragm does catch up, it, plus spring tension, moves the needle valve back on seat. This process continues until the high differential setting is reached. During the process, cabin pressure is held to a 1 psid increase per minute.


RATE OF CHANGE CONTROL SECTION
CONTROL SECTION ORIFICE ADJUSTMENT
CABIN AIR INLET
THREE WAY GROUND TEST VALVE (FLIGHT POS)
TO ATMOSPHERE

N-433

Frame 4 (Cont'd)

Answer the statements as true (T) or false (F).

1. The rate of change control section holds cabin pressure buildup to 1 psid per minute.

2. A too fast an increase in cabin pressure could injure the flight crew.

3. Head pressure builds up faster in the top of the control section than it does in the bottom.

4. If cabin pressure increases faster than 1 psid per minute, it may be because the adjustable orifice is opened too far.

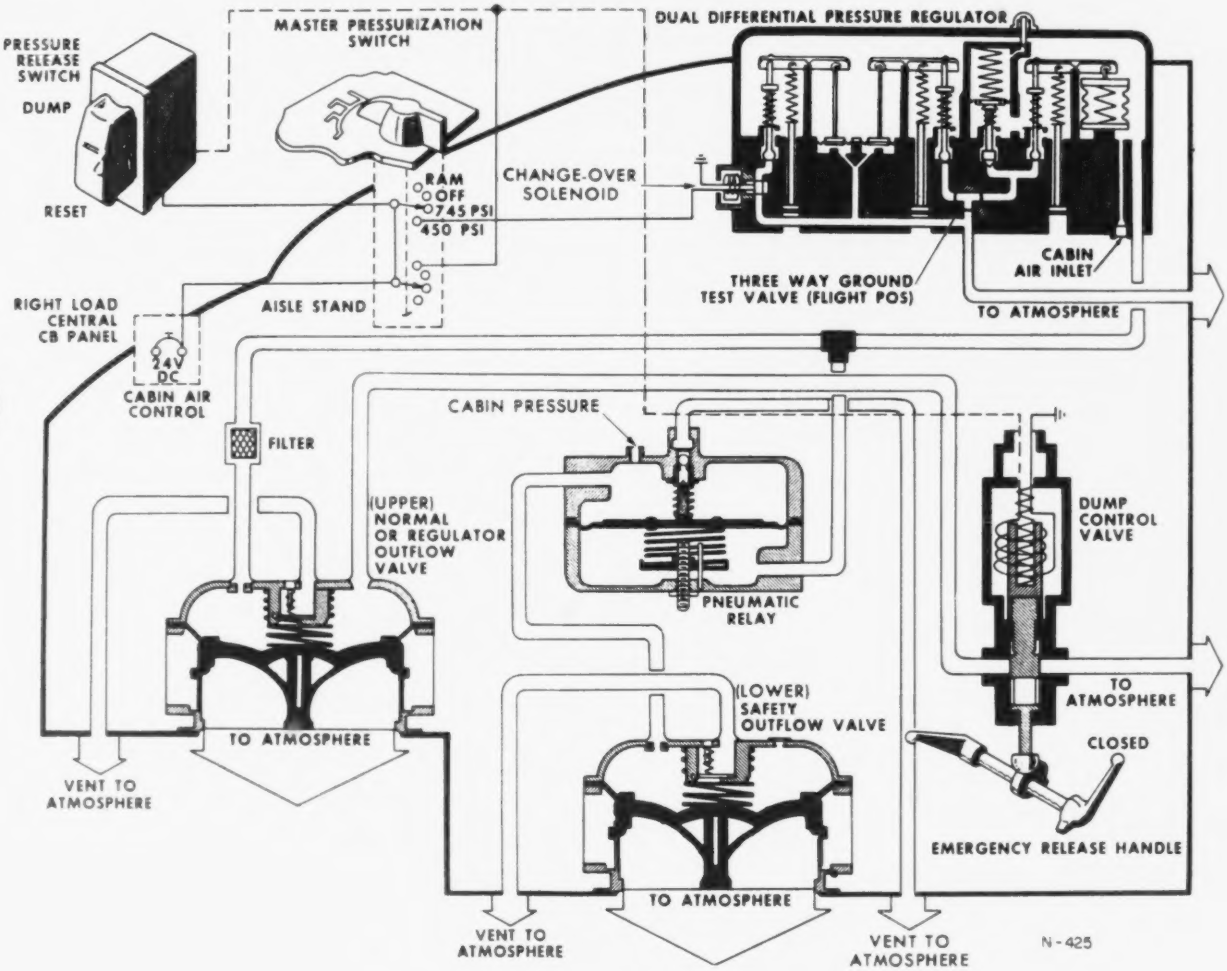
5. Cabin pressure tends to climb fast when the pilot changes the master pressurization switch from 4.50 psid to 7.45 psid.

Correct Responses to Frame 4: 1. T 2. T 3. F 4. T

5. T

Frame 5

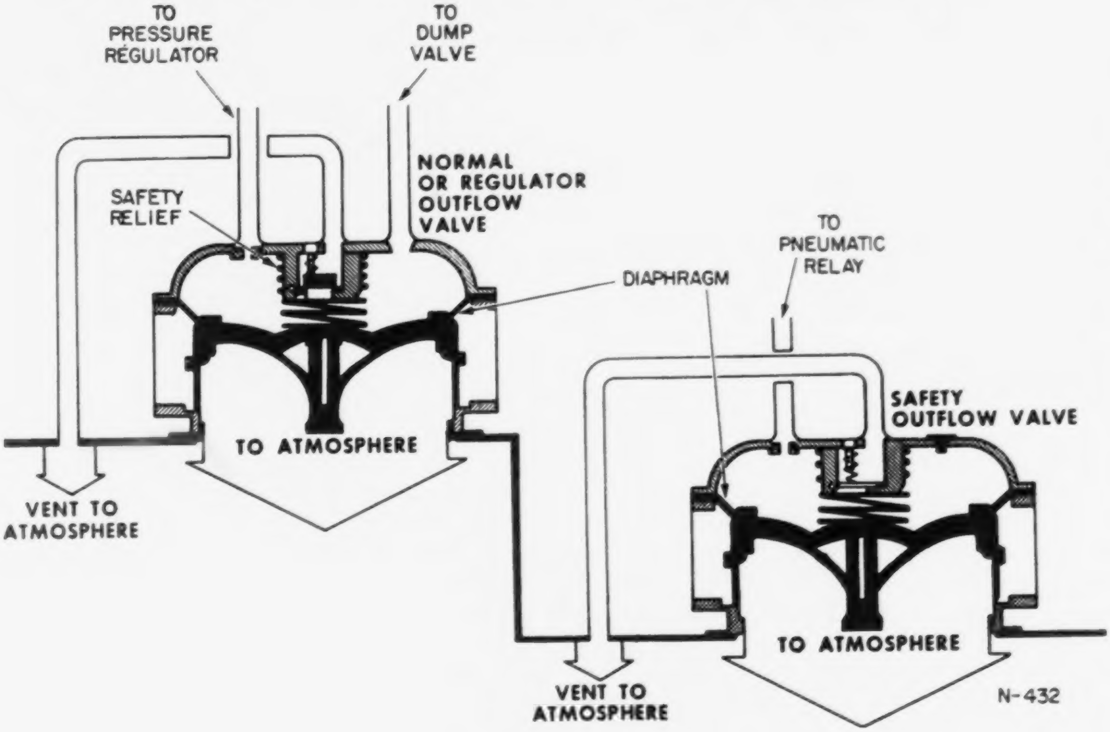
The crew compartment is too large for one outflow valve to take care of the great volume of air to be relieved. Therefore, the B-52 aircraft has two outflow valves. The difference between the two is that the normal or regulator outflow valve has three lines connecting to it. The safety outflow valve just has two. Both valves open to relieve high cabin pressure. They also relieve negative pressure at 0.36 psid.


PRESSURE RELEASE SWITCH
DUMP
RESET
MASTER PRESSURIZATION SWITCH
DUAL DIFFERENTIAL PRESSURE REGULATOR
RAM
OFF
7.45 PSI
4.50 PSI
CHANGE-OVER SOLENOID
AISLE STAND
THREE WAY GROUND TEST VALVE (FLIGHT POS)
CABIN AIR INLET
TO ATMOSPHERE
RIGHT LOAD CENTRAL CB PANEL
24V DC
CABIN AIR CONTROL
FILTER
CABIN PRESSURE
(UPPER) NORMAL OR REGULATOR OUTFLOW VALVE
PNEUMATIC RELAY
DUMP CONTROL VALVE
TO ATMOSPHERE
(LOWER) SAFETY OUTFLOW VALVE
CLOSED
EMERGENCY RELEASE HANDLE
TO ATMOSPHERE
VENT TO ATMOSPHERE
TO ATMOSPHERE
VENT TO ATMOSPHERE
VENT TO ATMOSPHERE
N-425

NO RESPONSE REQUIRED

Frame 6

In each of the outflow valves there is a safety relief section. Here is how it works. Suppose the pressure regulator failed to hold cabin pressure to 7.45 psid (high differential setting). When cabin and head pressures reach 8.1 psid the safety relief valves are pushed up and off seat. Head pressure can then vent to the atmosphere. Cabin pressure, which is now more than head pressure, will push the diaphragms up, open the outflow valves, and vent to the atmosphere.


TO PRESSURE REGULATOR
TO DUMP VALVE
SAFETY RELIEF
NORMAL OR REGULATOR OUTFLOW VALVE
DIAPHRAGM
TO PNEUMATIC RELAY
SAFETY OUTFLOW VALVE
TO ATMOSPHERE
VENT TO ATMOSPHERE
TO ATMOSPHERE
VENT TO ATMOSPHERE
N-432

Answer the statements as true (T) or false (F).

1. Each outflow valve contains a safety relief section.

2. Both outflow valves operate to relieve negative and cabin pressures.

3. Two outflow valves are used because of the size of the crew compartment.

4. Cabin pressure pushes the outflow valves off seat when the head pressure has been vented to the atmosphere.

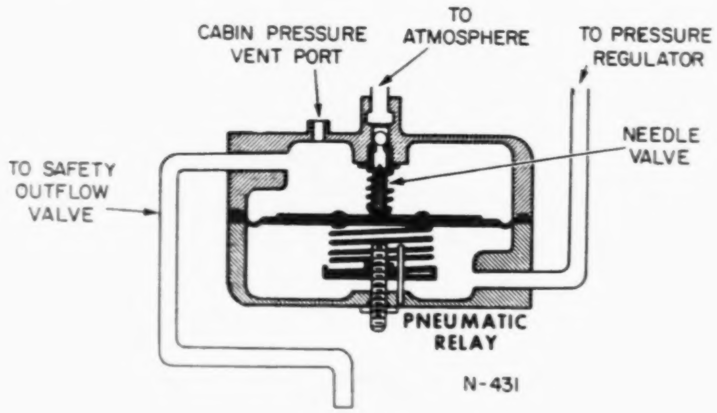
5. The two outflow valves are identical in construction and operation.

Correct Responses to Frame 6: 1. T 2. T 3. T 4. T

5. T

Frame 7

Look at the schematic in frame 5 and find the pneumatic relay. As you can see, this part is between the safety valve and pressure regulator. In the relay (see diagram) there is a diaphragm separating the top and bottom halves. On top of the diaphragm is a needle valve. It is held closed by the spring that pushes up on the bottom of the diaphragm. Cabin pressure is on both sides of the diaphragm. Pressure goes in the bottom half through the line that is connected to the regulator. Pressure goes in the top half through the cabin pressure vent port. Keep in mind the relay is placed inside the pressurized crew compartment.



Answer the statements as true (T) or false (F).

1. The relay is placed between the safety outflow valve and the pressure regulator.

2. The needle valve is held off seat by spring tension.

3. Cabin pressure acts on both sides of the diaphragm.

4. The relay is placed inside the cabin. Therefore, cabin pressure goes in the top of the relay through the cabin pressure vent port.

5. Cabin pressure in the bottom of the relay has to pass through the pressure regulator.

Correct Responses to Frame 7: 1. T 2. F 3. T 4. T 5. T

Frame 8

The job of the pneumatic relay is to make sure that the safety outflow valve operates fast. That does not tell you much but here is what it means.

You can not tell by looking at the schematic in frame 5, but the safety valve (in the lower crew compartment) and the pressure regulator are a long way from each other. The normal outflow valve is close to the regulator in the upper crew compartment. Keep in mind, the B-52 is a big aircraft. If there was no relay, the safety valve head pressure would have to vent through the regulator, just like the head pressure from the other outflow valve. By the time safety head pressure reached the regulator, the other outflow valve would have opened. Keep in mind, one outflow valve can not take care of the great volume of air to be relieved. The pneumatic relay makes sure that both outflow valves operate at the same time. The valve is the same distance from the regulator as the normal outflow valve. When the regulator kicks open (isobaric or differential operation) pressure is dumped from the bottom side of the pneumatic relay. The pressure in the top side of the relay can then push the diaphragm down. This will open the relay needle valve. Head pressure from the safety outflow valve can now vent past the relay needle valve to the atmosphere. The safety outflow valve opens and helps relieve cabin pressure. Safety reference pressure does not go back to the regulator to be vented, it vents through the relay valve. This lets the safety outflow valve operate quicker.

Answer the statements as true (T) or false (F).

1. The safety outflow valve is placed close to the regulator.

2. Safety outflow valve reference pressure will vent through the regulator.

3. Head pressure gets into the safety outflow valve from the top of the pneumatic relay.

4. The pneumatic relay is placed about half way between the two outflow valves.

5. The safety outflow valve is placed in the lower crew compartment while the normal outflow valve and the pressure regulator are placed in the upper crew compartment.

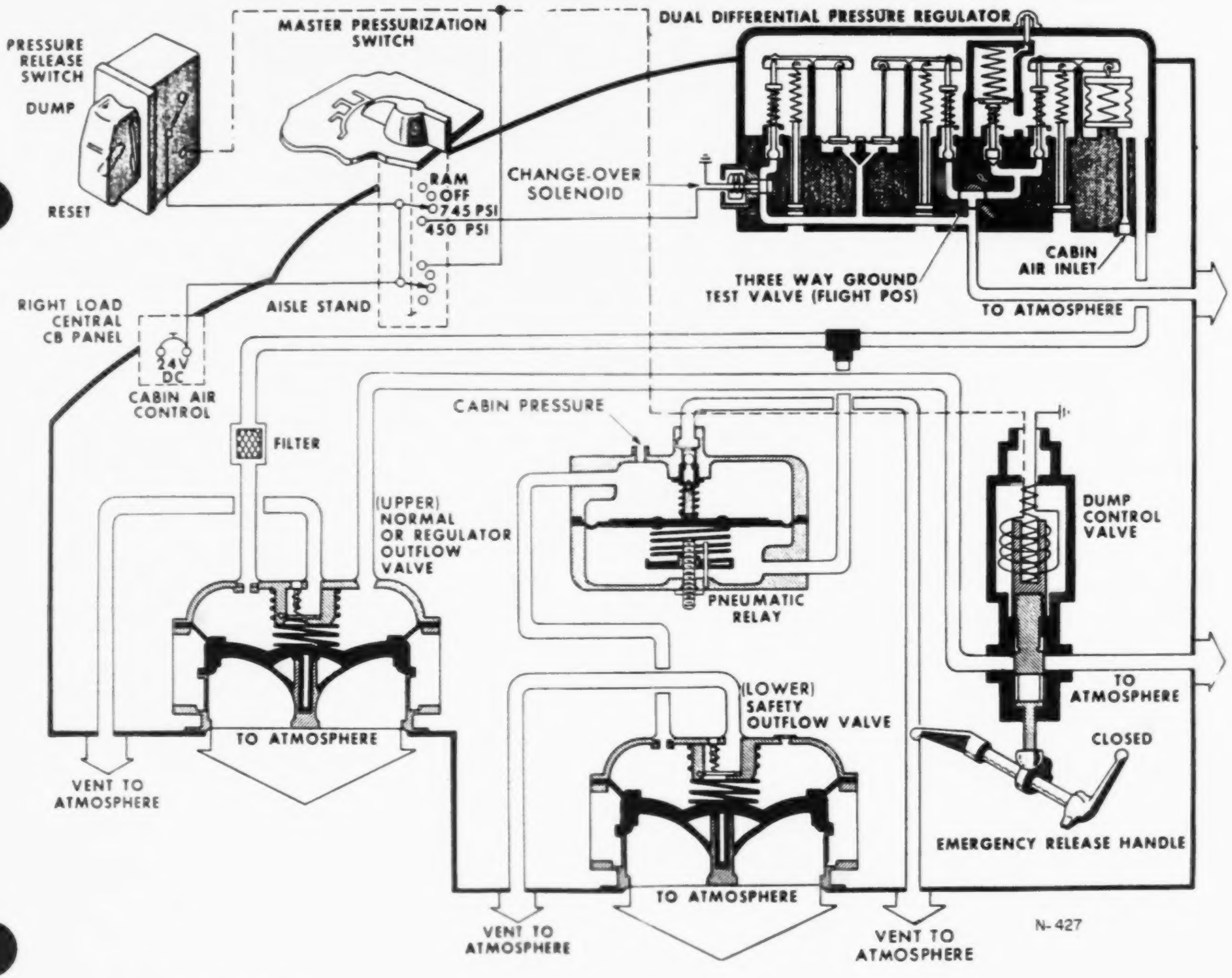
Correct Responses to Frame 8: 1. F 2. F 3. T 4. F

5. T

Frame 9

The dump valve can be operated electrically or manually. The valve job is to help dump cabin pressure in an emergency situation.

When the pilot puts the pressure release switch to the dump position, the dump valve is energized and the solenoid lifts the spool off seat. This dumps head pressure from the normal outflow valve. At the same time, pressure is dumped from the bottom side of the pneumatic relay through the normal outflow valve. Then through the dump valve. This will cause the relay needle valve to open and dump safety outflow valve head pressure. Both outflow valves open and cabin pressure is dumped to the atmosphere. All of this takes place in just a few seconds. The emergency release handle is used by the pilot in case electrical power fails to open the dump valve.


PRESSURE RELEASE SWITCH
DUMP
RESET
MASTER PRESSURIZATION SWITCH
DUAL DIFFERENTIAL PRESSURE REGULATOR
RAM
OFF
7.45 PSI
4.50 PSI
CHANGE-OVER SOLENOID
AISLE STAND
RIGHT LOAD CENTRAL CB PANEL
24V DC
CABIN AIR CONTROL
THREE WAY GROUND TEST VALVE (FLIGHT POS)
CABIN AIR INLET
TO ATMOSPHERE
CABIN PRESSURE
FILTER
(UPPER) NORMAL OR REGULATOR OUTFLOW VALVE
PNEUMATIC RELAY
DUMP CONTROL VALVE
TO ATMOSPHERE
(LOWER) SAFETY OUTFLOW VALVE
CLOSED
EMERGENCY RELEASE HANDLE
TO ATMOSPHERE
VENT TO ATMOSPHERE
TO ATMOSPHERE
VENT TO ATMOSPHERE
VENT TO ATMOSPHERE
N-427

Frame 9 (Cont'd)

Answer the statements as true (T) or false (F).

1. The dump valve can be operated manually.

2. The job of the dump valve is to help dump cabin pressure in an emergency situation.

3. The dump valve is normally operated electrically.

4. The pilot opens the dump valve by positioning the master pressurization switch.

5. The solenoid is deenergized to open the dump valve.

6. Head pressure from both outflow valves will vent through the dump valve.

Correct Responses to Frame 9: 1. T 2. T 3. T 4. F
5. F 6. F

PROGRAMMED TEXT
C3ABR42331-PT-315C

Technical Training

Aircraft Environmental System Mechanic

VARIABLE ISOBARIC PRESSURIZATION

22 July 1982

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: 9.1

1108

OBJECTIVE

Relate the terms associated with the operation of the cabin pressurization system with 80% accuracy.

INSTRUCTIONS

This program is presented in small steps called frames. After each frame you are asked to make a response to exercises. Enter your responses on the response sheet. DO NOT MARK IN THIS TEXT. In some instances you are asked to identify or match items. The correct answers are found at the beginning of each new frame. If your answer is correct, proceed to the next frame. If your answer is wrong, reread the material before you proceed to the next frame.

Supersedes 3ABR42331-PT-315C, 3 March 1981.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

The C-141 aircraft (plane) has an example of a pressurization system with a variable isobaric section. The whole system is made up of just three major parts. Look at the schematic (figure 1) on the next page and find the automatic controller, manual controller and the outflow/safety valve.

You probably noticed that this system does not have a cabin pressure regulator. That is because the three major parts of the system work together to regulate and control cabin pressure. Get familiar with the schematic for a few minutes then we will discuss each part individually.

NO RESPONSE REQUIRED

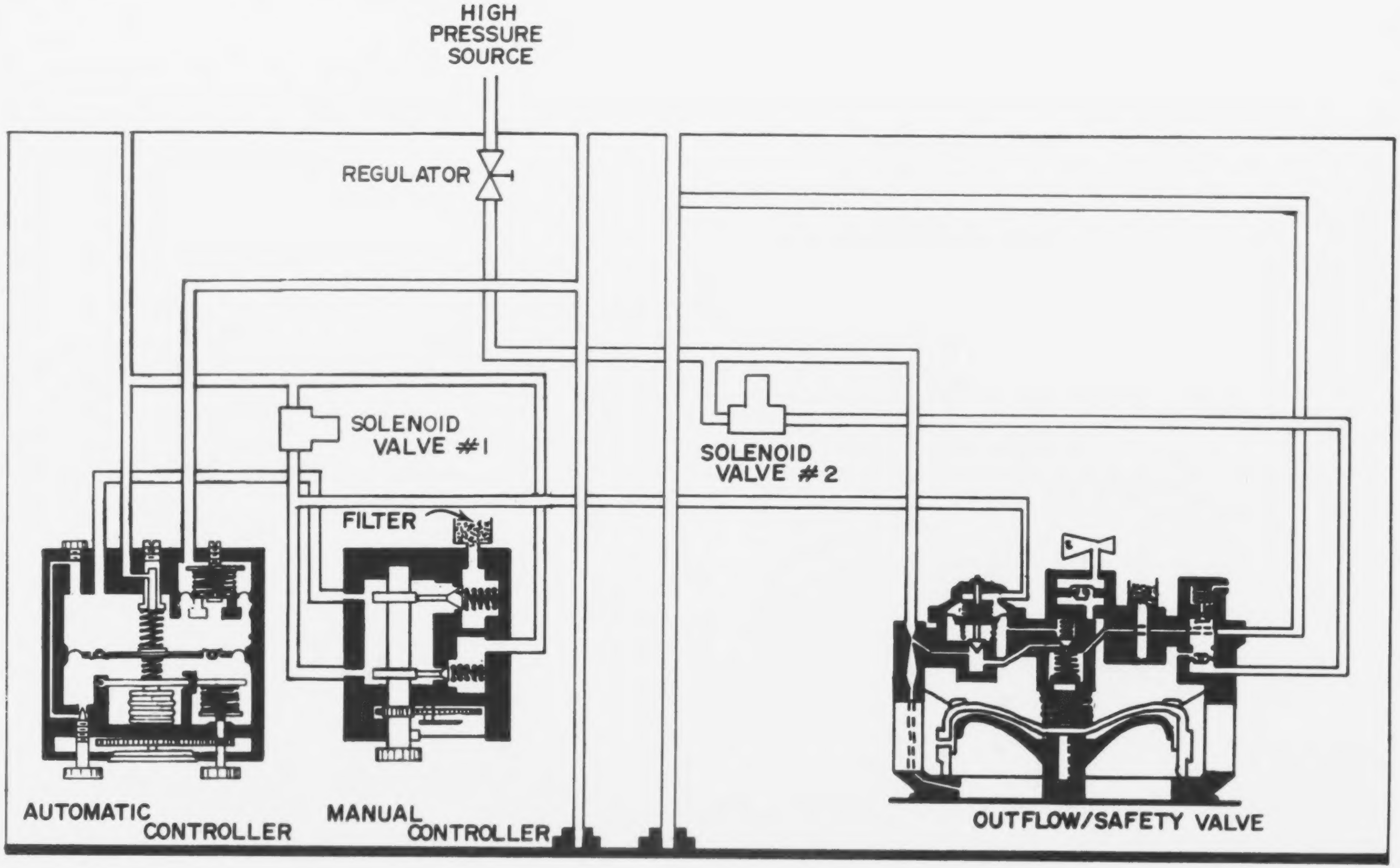
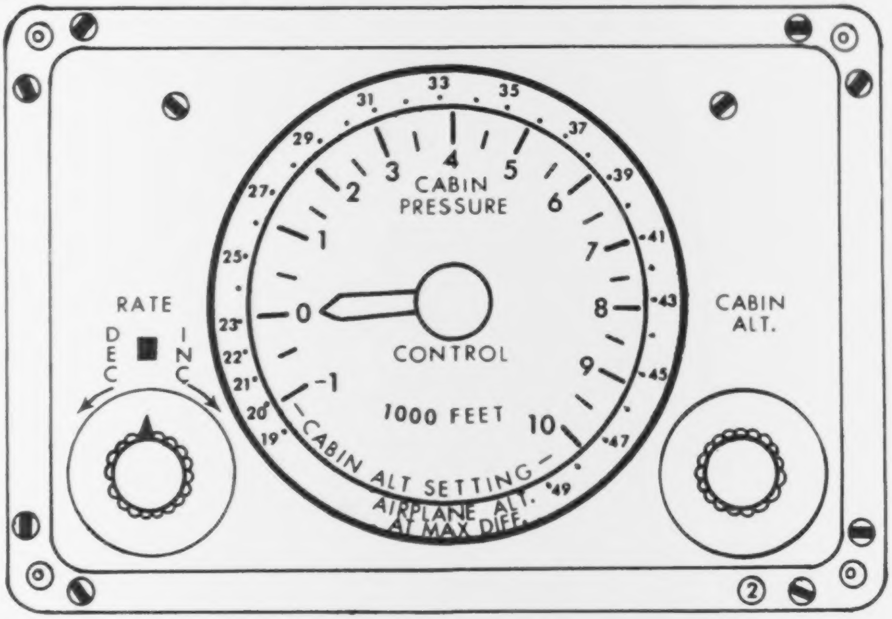

HIGH PRESSURE SOURCE
REGULATOR
SOLENOID VALVE #1
SOLENOID VALVE #2
FILTER
AUTOMATIC CONTROLLER
MANUAL CONTROLLER
OUTFLOW/SAFETY VALVE

Figure 1. Cabin Pressure Control Schematic.

Correct Response to Frame 1: None Required.

Frame 2

The first part is the automatic controller. It is made up of an isobaric section that can be set in flight, a rate control adjuster, and a differential section. The front of the automatic controller is shown in figure 2. The knob in the left is the rate control adjustment. The knob in the right is used to set the isobaric section. When this knob is turned, the dial hand turns in the same direction. The large numbers on the dial stand for cabin altitude in thousands of feet. The small numbers stand for the altitude of the plane in thousands of feet. For example: if the dial hand were set at 4 cabin pressure would be the same as atmospheric pressure at 4,000 feet. The plane, however, would be at approximately 30,000 feet, when the differential section caused cabin pressure to be vented out.


31
33
35
29
37
27
39
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41
23
43
22
21
45
20
19
47
49
-1
0
1
2
3
4
5
6
7
8
9
10
CABIN PRESSURE
CONTROL
1000 FEET
CABIN ALT SETTING
AIRPLANE ALT. AT MAX DIFF.
RATE
DEC
INC
CABIN ALT.
②

Figure 2. Automatic Controller.

Answer the statements as true (T) or false (F).

1. The knob in the left is the rate control adjustment.

2. The automatic controller is made up of an isobaric section, a rate control adjuster, and a differential section.

3. The knob in the right is used to set the differential.

4. The dial hand turns in the same direction as the cabin altitude knob.

Correct Responses to Frame 2: 1. T, 2. T, 3. F, 4. T.

Frame 3

Now let us take a look inside the automatic controller. In figure 3 you can see the differential, rate control and isobaric sections. The only difference between these and similar sections you have learned, is in the isobaric section. This one can be set in flight. We will go to this feature in the next frame.

The numbers at the top of the diagram stand for: (1) filter and orifice, (2) cabin air inlet port, (3) atmospheric vent, and (4) the atmospheric pressure inlet to the differential.

Use figure 3 to complete the following statements.

1. The atmospheric inlet to the differential section is number ______________________.

2. A diaphragm separates atmospheric pressure from cabin pressure at the ____________________ section.

3. The __________________ section is nothing more than an adjustable orifice.

4. The altitude selector knob is used to set the ____________ ____________________ section.

5. Port number 2 is the ___________________________ port.

6. Cabin pressure goes in the controller through port number ________________. To get to the isobaric section it must go through the __________________ and ________________ then the ____________________ section.

7. The atmospheric vent port is number ____________________.

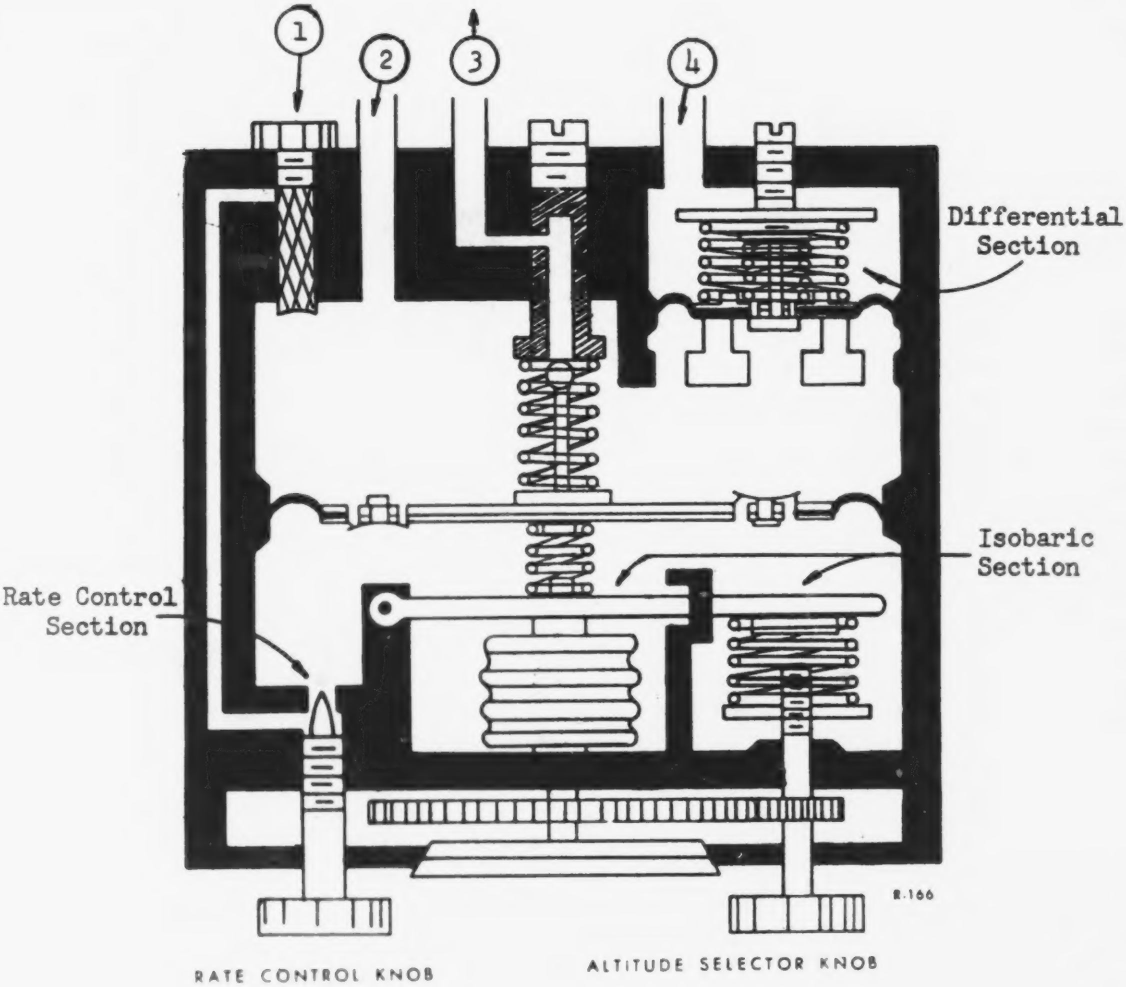

1
2
3
4
Differential Section
Isobaric Section
Rate Control Section
R-166
RATE CONTROL KNOB
ALTITUDE SELECTOR KNOB

Figure 3. Automatic Controller.

Correct Responses to Frame 3: 1. 4, 2. differential, 3. rate control, 4. isobaric, 5. cabin air inlet, 6. 2, filter, orifice, rate control, 7. 3.

Frame 4

Use figure 4. The isobaric section is made up of a lever, an aneroid, and adjustable spring. The aneroid is hooked to the lever that pivots on one end and rides on the spring at the other end. This means that all these parts must move together. When cabin pressure tries to squeeze the aneroid, the tension of the spring must be overcome before the lever can be pulled down. When the altitude selector knob is turned counterclockwise the spring is squeezed between the lever and the nut that moves up on the selector knob shaft. When the selector knob is turned clockwise the nut moves down on the shaft increasing spring tension. The higher the spring tension, the higher the altitude at which cabin pressurization starts. The lower the spring tension, the lower the altitude at which cabin pressurization starts. Do not try to figure this out right now. We will explain what we mean in the next frame.

Answer the statements as true (T) or false (F).

1. The isobaric section is made up of a lever, an aneroid and adjustable spring.

2. Cabin pressure squeezes the aneroid against spring tension.

3. Tension on the spring is set by turning the altitude selector knob.

4. The aneroid, lever, and spring do not move together.

5. The lower the tension on the spring, the higher the altitude at which pressurization starts

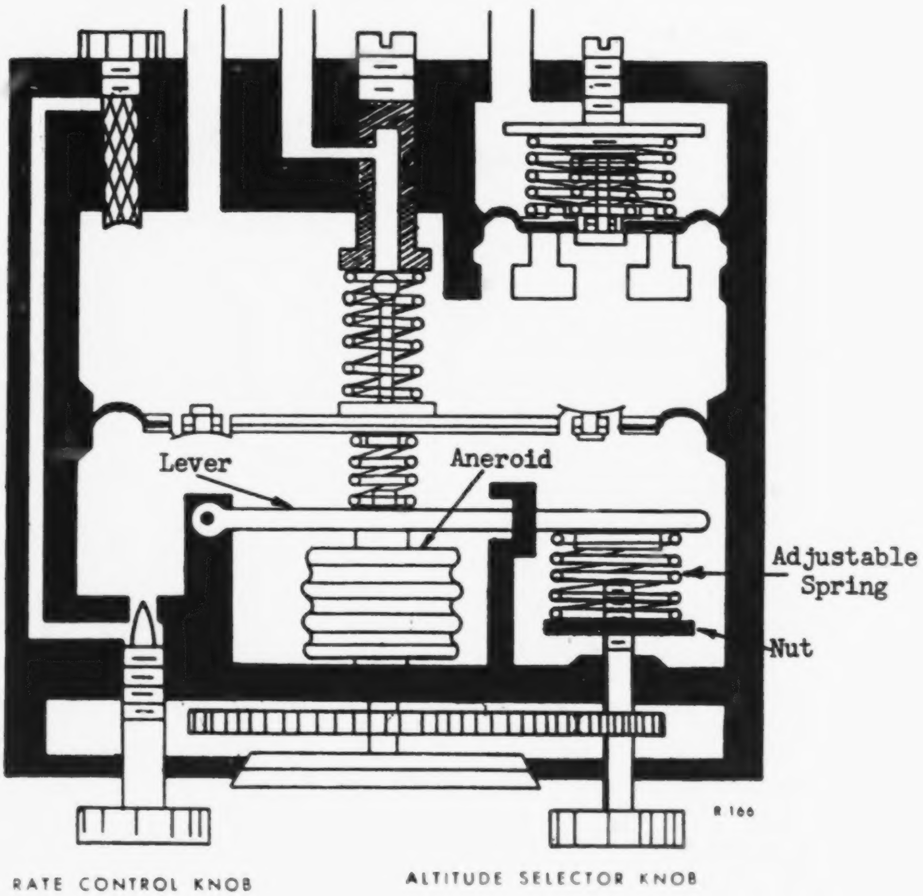

Lever
Aneroid
Adjustable Spring
Nut
R 166
RATE CONTROL KNOB
ALTITUDE SELECTOR KNOB

Figure 4. Automatic Controller.

Correct Responses to Frame 4: 1. T, 2. T, 3. T, 4. F, 5. F.

Frame 5

Use figure 5. Let us say the pilot wants his cabin pressurized to 8,000 feet in altitude (10.91 psia). He turns the altitude selector knob until the dial hand is on 8 (see figure 2). At this time the aneroid pressure (3 psia) and spring tension (7.91 lbs.) are the same as the atmospheric pressure at 8,000 feet (10.91 psia).

Keep in mind that when the plane is on the ground, atmospheric pressure (14.7 psia) would have the aneroid and spring (10.91 psia) squeezed flat. This means that as soon as the air conditioning system is turned on, the diaphragm will be pushed down and will open the vent valve. This lets the airflow to vent out to the atmosphere. Cabin pressure can not now build up.

Answer the statements as true (T) or false (F).

1. The pilot sets the desired cabin pressure by turning the rate control knob.
2. Pressure inside the aneroid is 3 psia.
3. Atmospheric pressure holds the vent valve on seat.
4. Cabin pressure must overcome the pressure in the aneroid and the adjustable spring tension before the vent valve will open.
5. The vent valve is closed and opened by the up and down movement of the diaphragm.

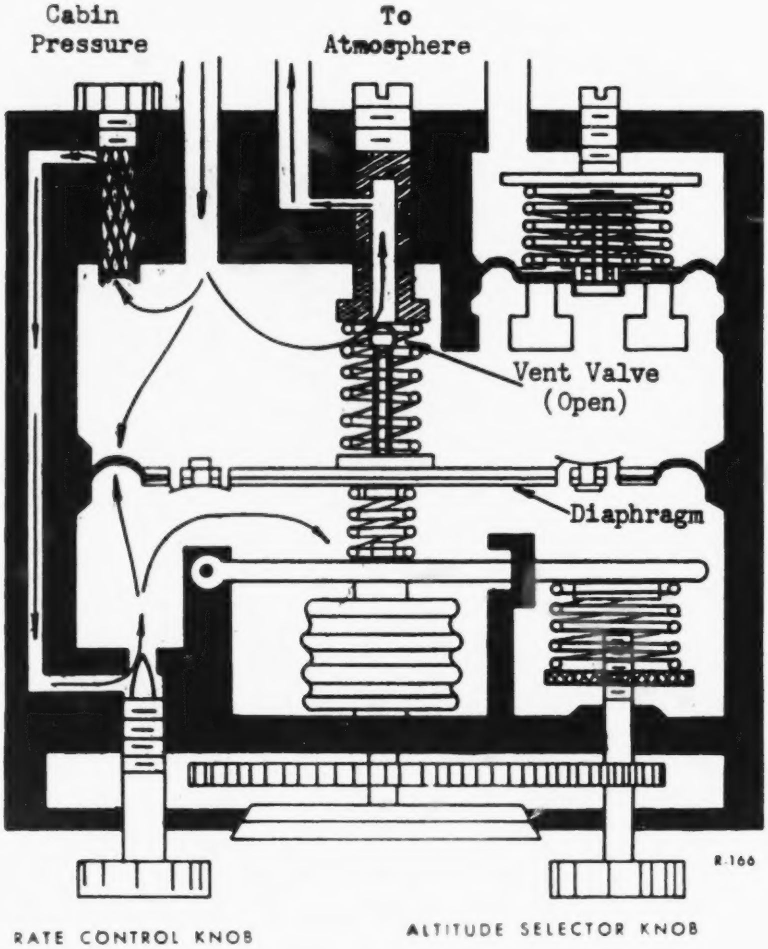

Cabin Pressure
To Atmosphere
Vent Valve (Open)
Diaphragm
R-166
RATE CONTROL KNOB
ALTITUDE SELECTOR KNOB

Figure 5. Automatic Controller.

Correct Responses to Frame 5: 1. F, 2. T, 3. F, 4. T, 5. T.

Frame 6

Use figure 6. A thing to keep in mind is that the automatic controller does not set cabin pressure. It is used to select an altitude at which cabin pressurization starts. So let us see how the isobaric section works as the plane starts to climb.

We have determined that with the controller set at 8, atmospheric pressure would have the aneroid squeezed and the vent valve would be open. We are now in the unpressurized range. At this time atmospheric pressure and cabin pressure are the same. As the plane climbs, atmospheric pressure drops. When the altitude of 8,000 feet is reached, cabin and atmospheric pressures drop below 10.91 psia. This pressure is on top of the controller diaphragm. At this point the aneroid and spring expand and push the vent valve ON seat. This lets cabin pressure build up. We are now in the isobaric range.

Answer the statements as true (T) or false (F).

1. The automatic controller automatically sets cabin pressure.
2. When the aneroid is squeezed, the vent valve will be open.
3. When the vent valve is open, cabin pressure cannot build up.
4. During the unpressurized range atmospheric pressure is more than cabin pressure.
5. The automatic controller is used to select an altitude at which pressurization starts.
6. Once the selected altitude is reached, the aneroid expands and the vent valve closes.
7. Cabin pressure will be automatically kept at the selected altitude in the isobaric range.

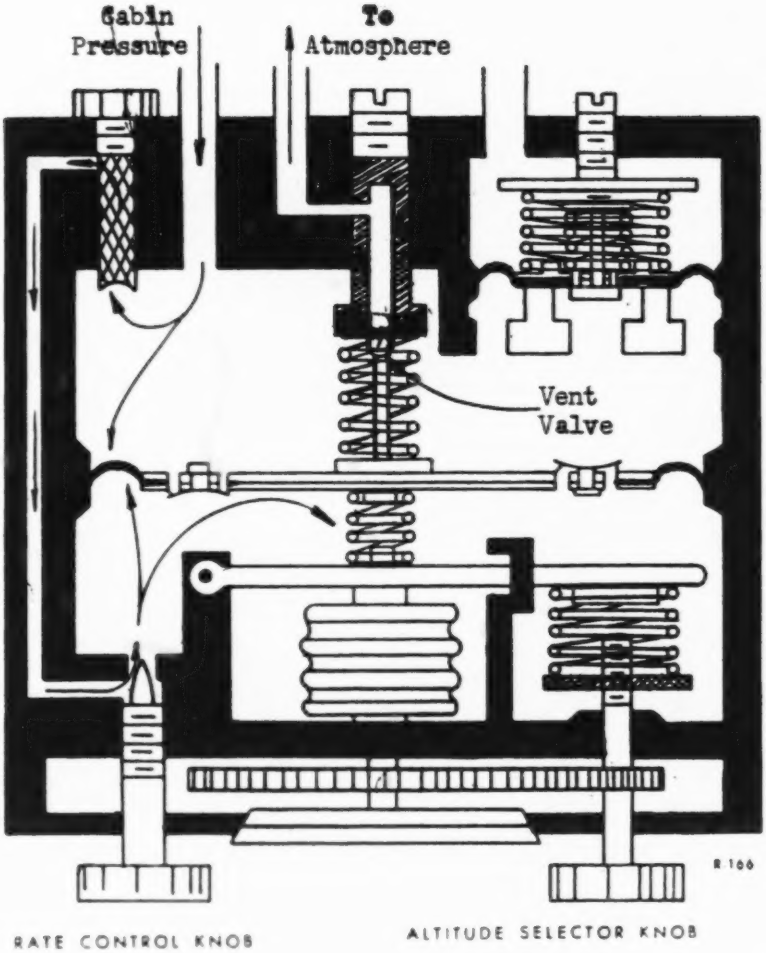

Cabin Pressure
To Atmosphere
Vent Valve
R 166
RATE CONTROL KNOB
ALTITUDE SELECTOR KNOB

Figure 6. Automatic Controller.

Correct Responses to Frame 6: 1. F, 2. T, 3. T, 4. F, 5. T, 6. T, 7. T.

Frame 7

Use figure 7. In the isobaric range, the aneroid will continue to squeeze and expand. This will close and open the vent valve and automatically keep cabin pressure at the desired setting (in this case 10.91 psia and 8,000 feet).

The differential section is set to work at 8.1 psid. As the plane climbs, atmospheric pressure on top of the differential diaphragm drops. When cabin pressure on the bottom of the diaphragm is more than that on top (atmospheric pressure plus spring tension) by 8.1 psid, the diaphragm moves up. This will open a path to the atmosphere. Cabin pressure in the top of the controller now goes through the differential opening. The vent valve will go on seat and will cause the isobaric section to become ineffective. The plane is in the differential range with the differential section controlling cabin pressure. If the plane continues to climb, cabin pressure will drop. However, the differential section will keep a cabin pressure of 8.1 psid more than atmospheric pressure (while in the differential range), even though the altitude of the plane may change.

Answer the statements as true (T) or false (F).

1. In the isobaric range, operation of the aneroid automatically controls cabin pressure.
2. The differential section is set to work at 10.91 psid.
3. As aircraft altitude increases, atmospheric pressure drops.
4. Cabin pressure pushes the differential diaphragm up and atmospheric pressure plus spring tension pushes it down.
5. When the differential opens a path to the atmosphere, pressure underneath the controller diaphragm pushes the vent valve up and ON seat.
6. While in the differential range, cabin pressure will be kept at 8.1 psid more than atmospheric pressure even though the altitude of the plane may change.
7. During the differential range, if atmospheric pressure were 3.57 psia, cabin pressure would be 10.91 psia.

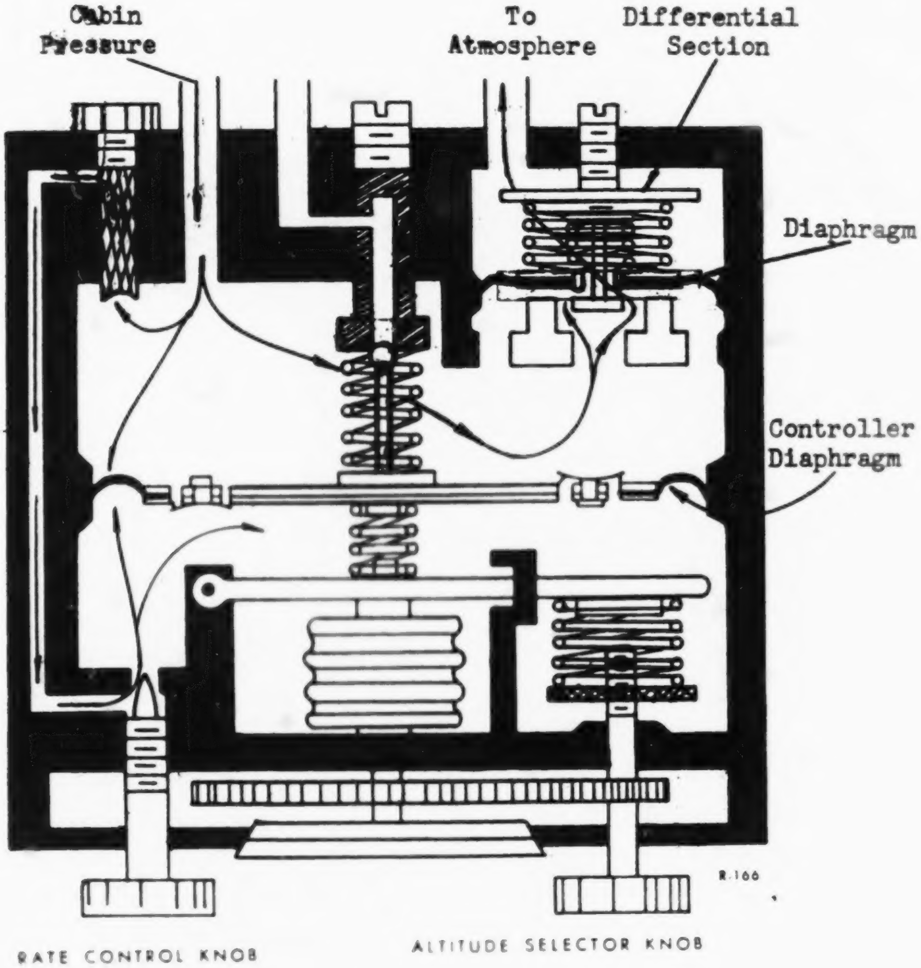

Cabin Pressure
To Atmosphere
Differential Section
Diaphragm
Controller Diaphragm
R-166
RATE CONTROL KNOB
ALTITUDE SELECTOR KNOB

Figure 7. Automatic Controller.

Correct Responses to Frame 7: 1. T, 2. F, 3. T, 4. T, 5. T, 6. T, 7. F.

Frame 8

The C-141 aircraft is often used as a troop carrier. Sometimes the troops are hurt or ill and are flown to a hospital for treatment. The rate of change control section protects these people, as well as the flight crew, from a rapid fast rise in pressure. It does this by limiting the buildup of cabin pressure. The rate of pressure change is the same as a rise in altitude of between 200 and 2,000 feet per minute. Look at figure 5 as we give the operation of the rate control section.

Cabin pressure flows in the top of the controller, through the filter. Pressure flows past the adjustable rate control orifice, and in the bottom of the controller. Since the flow in the top chamber is not restricted, pressure builds up faster there than it does in the bottom chamber. The controller diaphragm is forced down, and pulls the vent valve open. This will let part of the cabin pressure to vent to the atmosphere. Soon the pressure in the lower chamber catches up and pushes the diaphragm up. This will close the vent valve. This whole process has limited the rate at which cabin pressure will build up.

If the orifice is opened all the way, the rise in cabin pressure will be at a rate that is the same as that of a 2,000 feet per minute altitude rise. The minimum is the same as a 200 feet per minute altitude rise. The pilot can change the size of the orifice by turning the rate control knob. He has a gage in the cockpit which shows him the rate of change in feet per minute.

Answer the statements as true (T) or false (F).

1. The rate of change control section protects personnel from a fast rise in pressure.

2. The rate control section can be set between 200 and 2,000 feet per minute rate of change.

3. Cabin pressure flows in the bottom of the controller faster than it flows in the top.

4. The rate control orifice is set when the pilot turns the rate control knob on the automatic controller.

5. When pressure in the lower chamber of the controller catches up with the pressure in the upper chamber, the vent valve will be forced ON seat.

Correct Responses to Frame 8: 1. T, 2. T, 3. F, 4. T, 5. T.

Frame 9

Look at figure 1 and find the manual controller. With this part the pilot can manually adjust and control cabin pressure if the automatic controller fails.

Follow each of the lines leaving the manual controller to see where they hook into the rest of the system.

NO RESPONSE REQUIRED

Correct Response to Frame 9: None Required.

Frame 10

Use figure 8. Due to the arrangement of the two cams, the inlet and outlet valves work at the same time, but in opposite directions. If the knob were turned clockwise (more pressure) the inlet valve would start to move OFF seat. The outlet valve would start to move ON seat. Keep in mind, the pilot uses this valve ONLY when the automatic controller fails, let us say the vent valve sticks on seat.

As the inlet valve opens, the outlet valve will close, restricting the amount of air that will vent overboard. This will cause cabin pressure to rise. To drop cabin pressure the pilot turns the knob counterclockwise and the valves move just the opposite as before. The idea is for the pilot to get the valves set just right so that cabin pressure is kept at a desired rate.

Answer the statements as true (T) or false (F).

1. The inlet and outlet valves work at the same time.
2. Cabin pressure enters the manual controller through the filter and orifice.
3. If the knob were turned clockwise, cabin pressure would drop.
4. The manual controller is used to aid the automatic controller in dumping cabin pressure.
5. Cabin pressure must go through the manual controller to get to the automatic controller.

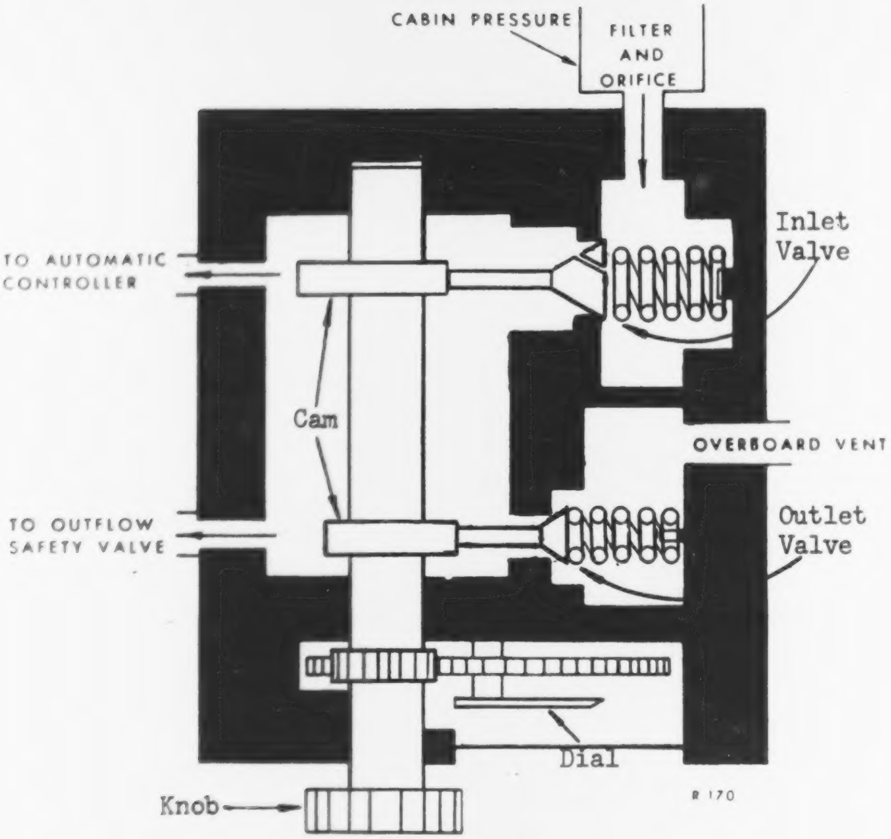

CABIN PRESSURE
FILTER AND ORIFICE
Inlet Valve
TO AUTOMATIC CONTROLLER
Cam
OVERBOARD VENT
TO OUTFLOW SAFETY VALVE
Outlet Valve
Dial
Knob
R 170

Figure 8. Manual Controller.

Correct Responses to Frame 10: 1. T, 2. T, 3. F, 4. F, 5. T.

Frame 11

Take a look at the schematic on foldout 1 and find the outflow/safety valve. This valve has several parts important to the function of the pressurization system. The first of these parts that we will discuss is the pneumatic relay. It is placed in the upper left corner of the outflow/safety valve. The job of the relay is to cause a fast response of the outflow valve when the vent valve in the automatic controller opens. Here is how it works.

When the vent valve is opened, cabin pressure in the top of the automatic controller will vent to the atmosphere. Look at the schematic and follow the arrows from the relay. If you will recall Pascals' Law, you can see that when pressure drops in the top of the controller, it drops the same amount in the top of the relay and at the same time. Both chambers have the same confined air. When just a small amount of pressure is dumped from the top of the relay, head pressure will push the relay diaphragm up and opens the needle valve. Head pressure will now vent to the atmosphere through the passageway out of the bottom of the outflow/safety valve. Cabin pressure lifts the outflow valve off seat and vents to the atmosphere.

Answer the statements as true (T) or false (F).

1. The pneumatic relay causes a faster response of the outflow valve when the vent valve opens in the automatic controller.

2. Pressure in the top of the pneumatic relay is the same as that in the top of the automatic controller.

3. Head pressure lifts the outflow valve off seat.

4. A large amount of pressure must be relieved on top of the relay before the needle valve is lifted off seat.

5. When the relay needle valve is moved off seat, head pressure is vented to the atmosphere and the outflow valve opens.

Correct Responses to Frame 11: 1. T, 2. T, 3. F, 4. F, 5. T.

Frame 12

A jet pump is placed in the outflow/safety valve to help the relay open the outflow valve quick. Look at figure 9. The jet pump works like a venturi. As engine bleed air (regulated to 16 psi) is forced through the pump, air speed will rise. Pressure will drop where the passageway is the smallest. This tends to suck the head pressure out past the relay needle valve that will cause the outflow valve to open immediately. Keep in mind, this will all happen when the vent valve in the automatic controller comes off seat.

Number each of the events in the order in which it takes place.

_____a. Cabin pressure will open the outflow valve and vent to the atmosphere.

_____b. The vent valve in the automatic controller will open when cabin pressure overcomes the setting of the isobaric aneroid.

_____c. The relay needle valve opens to let head pressure to be sucked out by the jet pump.

_____d. Pressure on top of the relay diaphragm is dumped through the manual controller and out the vent valve in the automatic controller.

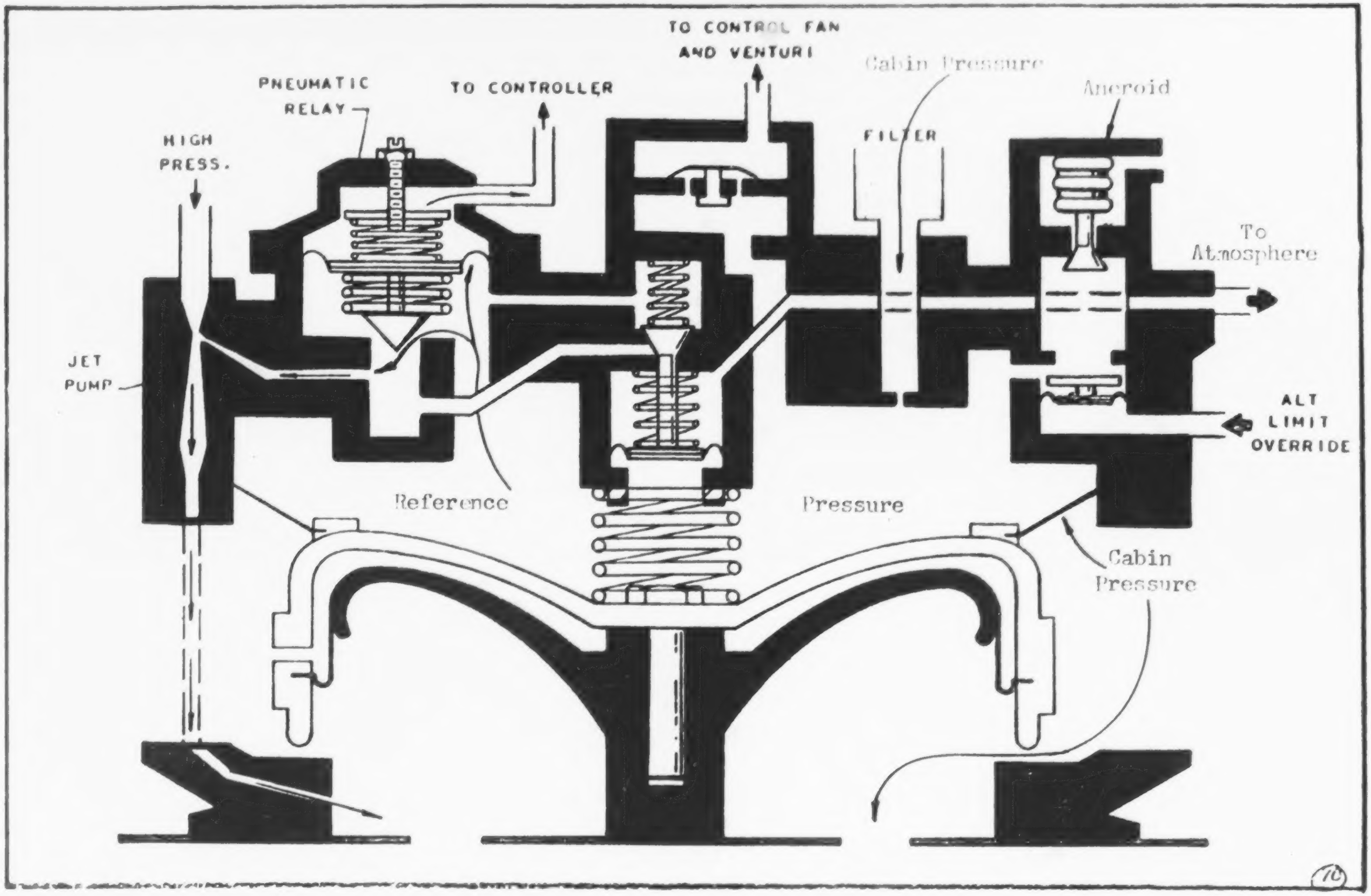

TO CONTROL FAN AND VENTURI
Cabin Pressure
PNEUMATIC RELAY
TO CONTROLLER
Aneroid
HIGH PRESS.
FILTER
To Atmosphere
JET PUMP
ALT LIMIT OVERRIDE
Reference
Pressure
Cabin Pressure
(10)

Figure 9.

Correct Responses to Frame 12: 4 a. 1 b. 3 c. 2 d.

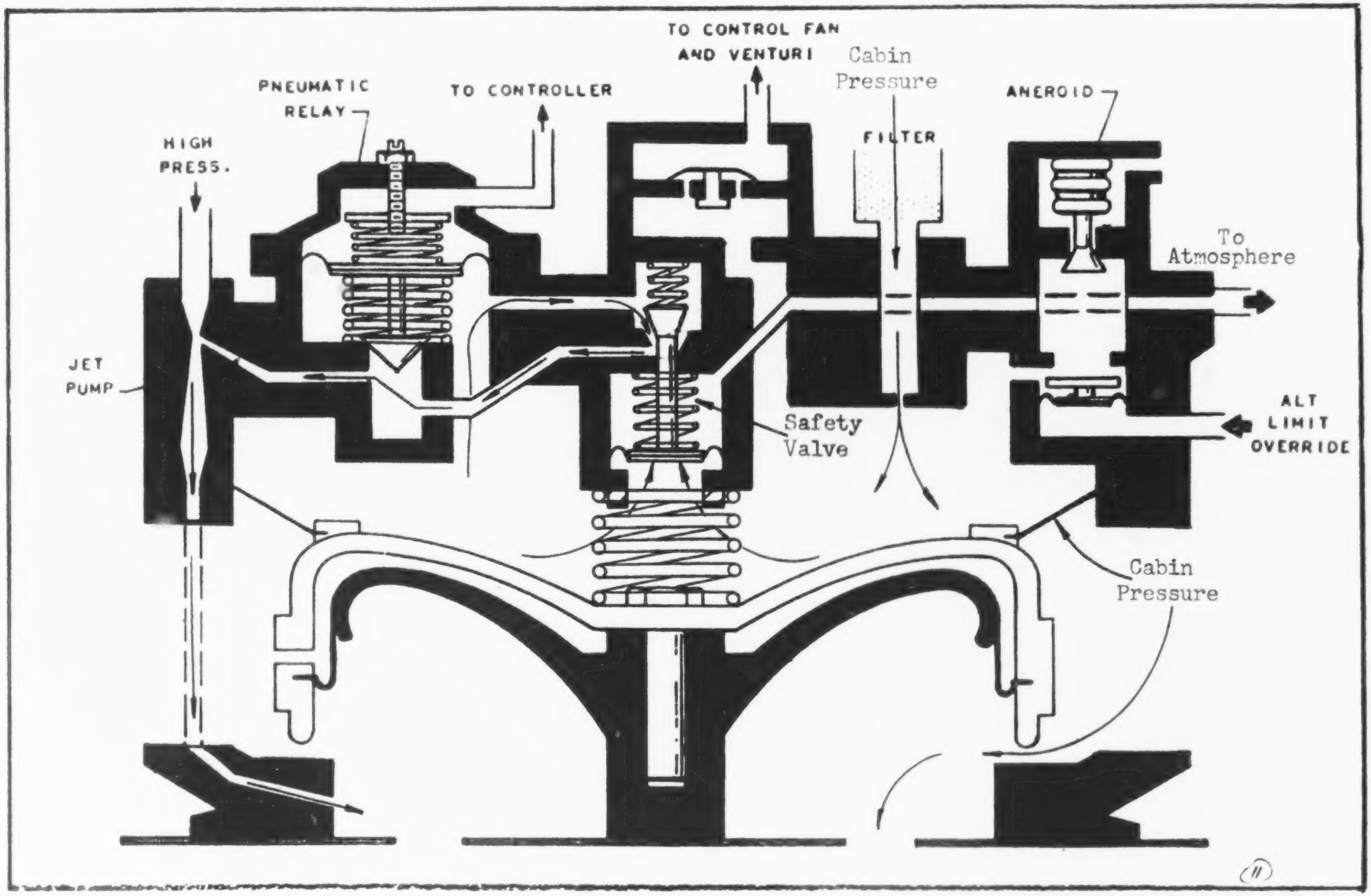
Frame 13

The safety valve protects the plane and flight crew from too much cabin pressure if the differential section fails to work. The differential section is supposed to work at 8.1 psid. If it does not, the safety valve will open at 8.6 psid.

Look at figure 10 and see that atmospheric pressure is on top of the safety valve diaphragm. If head pressure underneath the diaphragm is 8.6 psid more than the atmospheric pressure on top, the diaphragm is forced up and the safety valve will open. Head pressure rushes past the opened safety valve to the jet pump. Here it is sucked out and vented overboard. Cabin pressure will push the outflow valve open and vent to the atmosphere.

Answer the statements as true (T) or false (F).

1. If the differential section fails, the safety valve will control cabin pressure and keep it at 8.1 psid.
2. Atmospheric pressure is acting on top of the safety valve diaphragm.
3. Once the safety valve is opened, head pressure is dumped rapidly due to the work of the jet pump.
4. Cabin pressure opens the outflow valve when head pressure exceeds atmospheric pressure by 8.6 psid.
5. The job of the safety valve is to protect the plane and flight crew from too much cabin pressure.


TO CONTROL FAN
AND VENTURI
Cabin
Pressure
PNEUMATIC
RELAY
TO CONTROLLER
ANEROID
HIGH
PRESS.
FILTER
To
Atmosphere
JET
PUMP
Safety
Valve
ALT
LIMIT
OVERRIDE
Cabin
Pressure
(11)

1133

1134

Figure 10.

Correct Responses to Frame 13: 1. F, 2. T, 3. T, 4. T, 5. T.

Frame 14

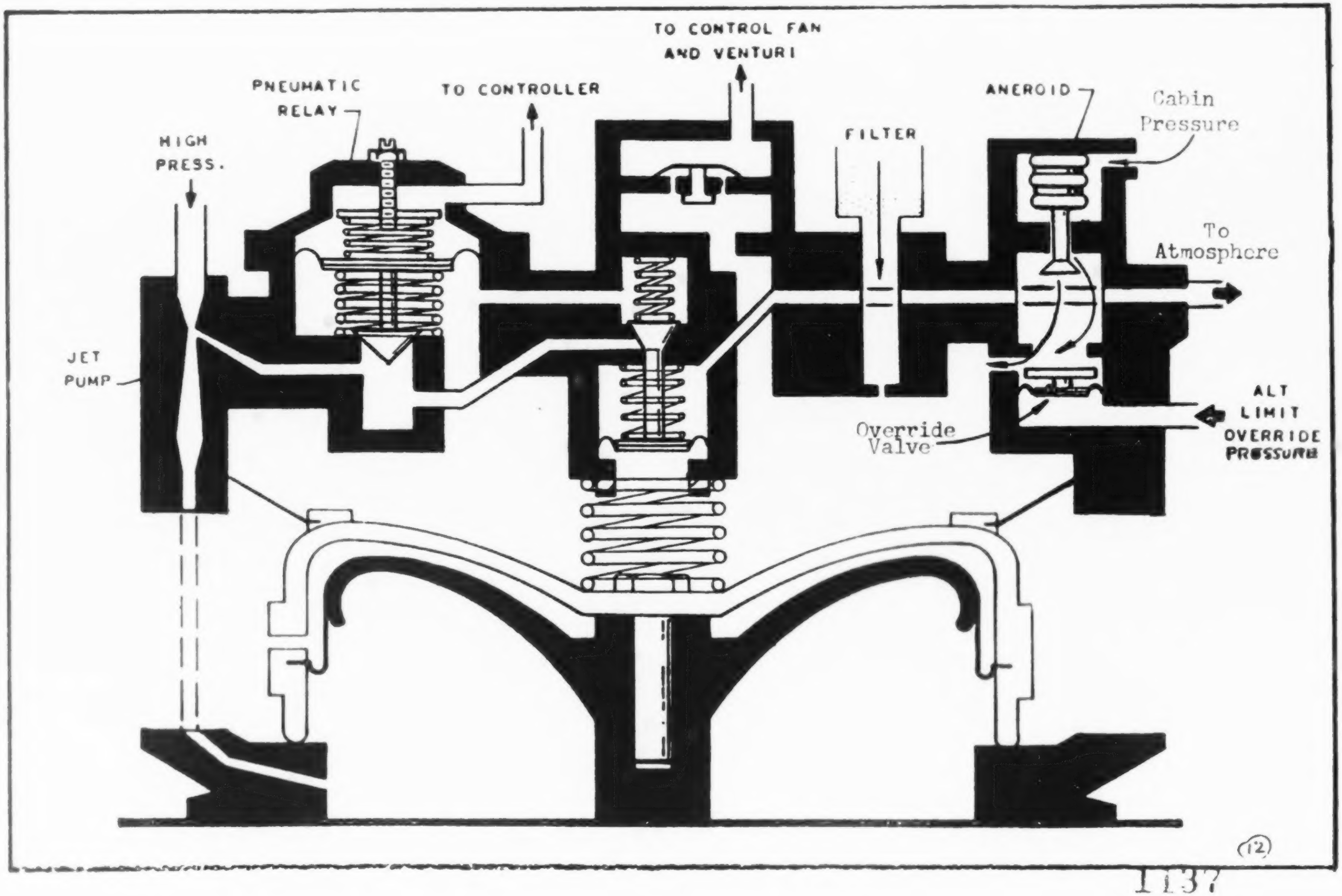
We just learned how the C-141 safety valve protects the flight crew and passengers from too much cabin pressure. The plane also has a feature which makes sure that cabin pressure does not get too low. This feature is provided by the aneroid and override valve shown in the top right corner of figure 11. The aneroid has 8.81 psia. As long as the system is in the normal mode of operation, it is kept squeezed by cabin pressure. Let us find out when and how it expands and what happens when it does.

Suppose the pilot has the automatic controller set at 8 and the plane is flying at 40,000 feet. This means cabin pressure will be kept at 10.91 psia. If, for some reason, the vent valve in the automatic controller opened or started to leak, the relay would open the dump head pressure. This would let the outflow valve open and cabin pressure would start to drop. When the pressure drops to 8.81 psia, the aneroid will expand and open an additional path for cabin pressure to go to the top of the outflow diaphragm. Due to this addtional path, cabin pressure will now go in the head pressure chamber faster than it can leak out. This will cause the outflow valve to close and keep cabin pressure from dropping to 2.73 psia (atmospheric pressure at 40,000 feet). The aneroid will continue to open and close to control cabin pressure at 8.81 psia that is the same as a 13,500 feet altitude.

If, however, the pilot wants cabin pressure to be lower than 8.81 psia, he sets an override switch that is on his control panel. This will cause solenoid valve #2 (see foldout 1) to open. Engine bleed air is then sent to the bottom of the override valve. The override valve will close and make the aneroid operation ineffective. Now, the pilot can open solenoid valve #1 or the manual controller and drop cabin pressure as low as he wants it. This procedure would need to be used in paratroop or cargo drops when atmospheric pressure is less than 8.81 psia. To make these drops the cargo doors have to be opened. The pilot would want to lower cabin pressure gradually until it is the same as atmospheric pressure. If he did not drop cabin pressure beforehand, there would be such a fast decompression when the cargo doors were opened that the cargo and personnel alike would possibly be blown out of the opening.

Answer the statements as true (T) or false (F).

1. The small aneroid keeps cabin pressure from becoming too high.
2. The override valve is closed by engine bleed air.
3. The aneroid has 8.81 psia.
4. When the aneroid expands, cabin pressure comes in the head pressure chamber faster than it can get out and the outflow valve will close.
5. Unless the override valve is closed, the aneroid will keep cabin altitude to 13,500 feet.


TO CONTROL FAN AND VENTURI
PNEUMATIC RELAY
TO CONTROLLER
ANEROID
Cabin Pressure
FILTER
HIGH PRESS.
To Atmosphere
JET PUMP
ALT LIMIT OVERRIDE PRESSURE
Override Valve
(12)

1136

1137

Figure 11.

Correct Responses to Frame 14: 1. F, 2. T, 3. T, 4. T, 5. T.

Frame 15

When the C-141 aircraft lands, the outflow valve opens automatically to let cabin pressure equalize with the atmospheric pressure. A squat switch on the landing gear shock strut (when the weight of the plane sets on it) turns on the control fan shown in figure 12. The fan draws air through a venturi creating a low pressure or suction. This pulls the small diaphragm open and vents head pressure overboard. The outflow valve opens allowing cabin and atmospheric pressures to be the same.

NO RESPONSE REQUIRED

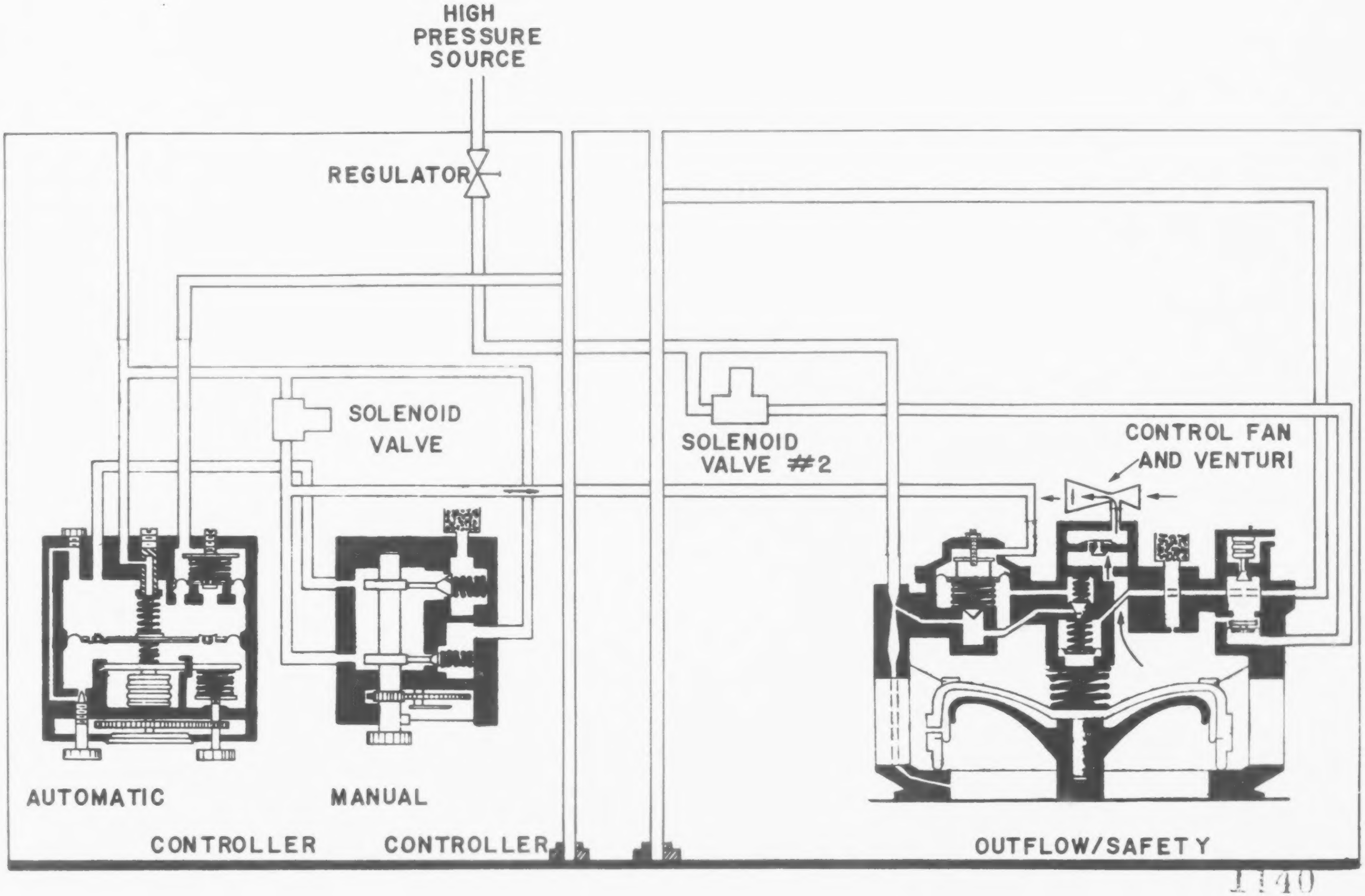
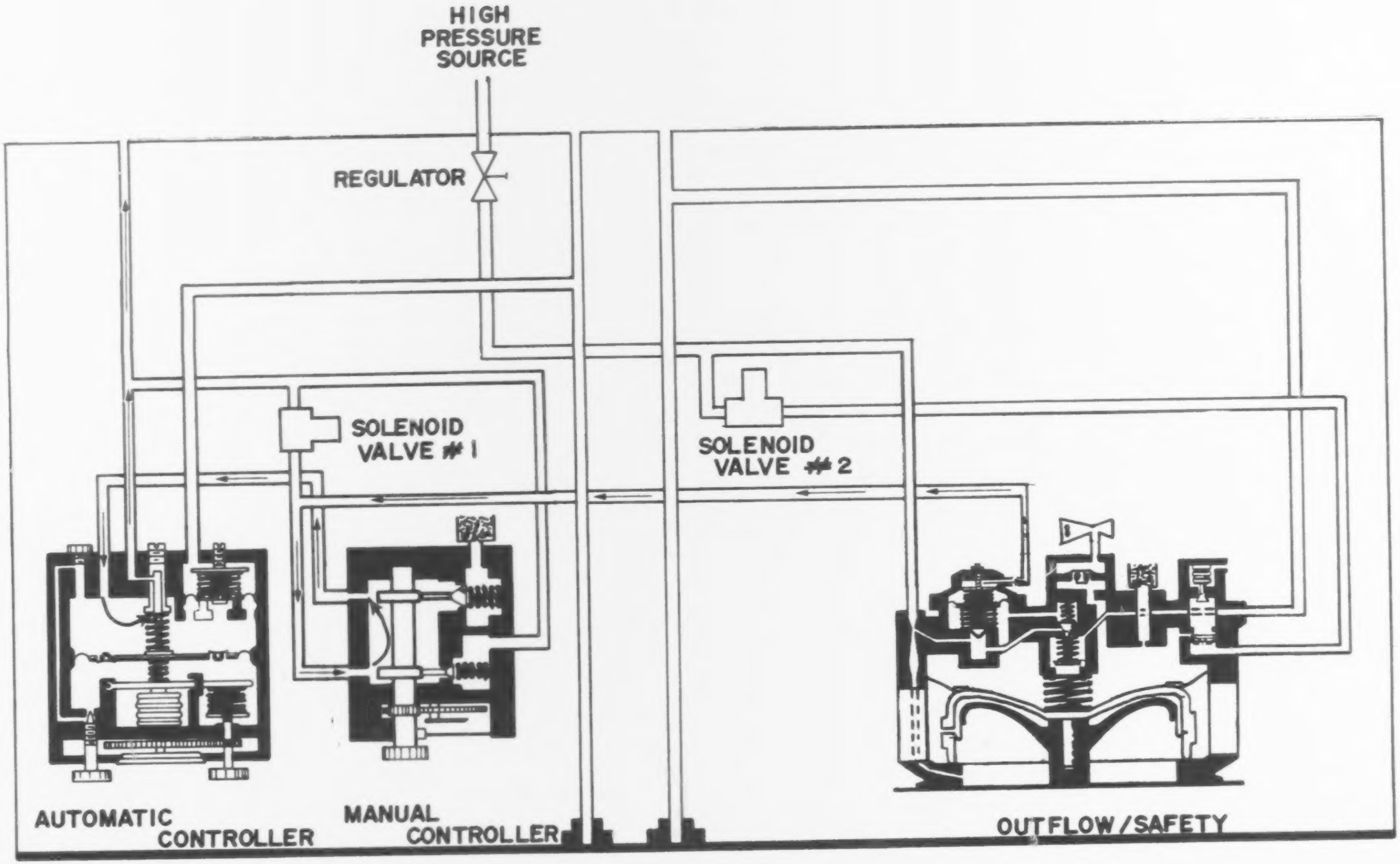

HIGH PRESSURE SOURCE
REGULATOR
SOLENOID VALVE
SOLENOID VALVE #2
CONTROL FAN AND VENTURI
AUTOMATIC
MANUAL
CONTROLLER
CONTROLLER
OUTFLOW/SAFETY

Figure 12.


HIGH PRESSURE SOURCE
REGULATOR
SOLENOID VALVE #1
SOLENOID VALVE #2
AUTOMATIC CONTROLLER
MANUAL CONTROLLER
OUTFLOW/SAFETY

70-08431

1141

1142

WORKBOOK
C3ABR42331-WB-316A

Technical Training

Aircraft Environmental System Mechanic

CABIN PRESSURE LEAKAGE CHECK

11 January 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

Environmental Pneudraulic Branch
Chanute AFB, Illinois

C3ABR42331-WB-316A

CABIN PRESSURE LEAKAGE CHECK

OBJECTIVE

Using a cabin pressure leakage tester, the necessary tools, and the applicable TO, and working in a group of not more than four students, perform a cabin pressure leakage test and troubleshoot the CT-5 trainer with a maximum of three instructor assists.

> Note: An instructor assist is limited aid; such as location of components, technical directions or explanations, and/or technical order interpretation given to students who can proceed no further on their own. Any of the following items will also constitute an assist: (1) not following technical order directions, (2) improper use of handtools, (3) not following the workbook sequence, (4) misuse of government equipment, and (5) safety violations constitute an automatic failure.

EQUIPMENT

CT-5, F-111 Trainer
MB-3 Cabin Leakage Tester
Intercom Headset
Applicable Handtools
TO 1F-111A-2-2-1
TO 33A4-4-10-1

INTRODUCTION

You have learned that some aircraft compartments are pressurized so that a flight crew can sustain life and function effectively at high altitudes. One of the jobs of the Environmental Systems Repairman is to check the cockpits and/or cabins of various aircraft for too much pressure leakage. We say "too much" because the airplane is made to allow for some leakage for ventilation. The flow of air from the environmental system (the cooling turbine) is more than enough to keep the selected cabin pressure at all altitudes and flight conditions. Sometimes the leakage is so great that the air supply cannot keep up and cabin pressurization is lost. When this happens, the Environmental Systems Repairman must find the leak and repair it if possible. It is sometimes hard to find an air leak and practically impossible with the aircraft in flight. Therefore, cabin pressure leakage checks are made on the ground using a cabin leakage tester to simplify this difficult task.

PROCEDURE

Before a cabin pressure leakage test is made, you should familiarize yourself with the steps listed in the Technical Order.

Supersedes 3ABR42331-WB-316A, 7 August 1981, which may be used until existing stocks are exhausted.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

To do this we will have you use the TO to answer some questions about the test. After this is done, tell the instructor that you are ready to make a cabin pressure leakage test.

Now, get TO 1F-111A-2-2-1 from the file and answer the questions and complete the following statements:

Caution: The pressure leakage test is hazardous. Be sure you know each step before you go to the next.

1. Which section of the TO is for the cabin pressure leakage checkout? ______________________________.

a. Turn to the correct section.

b. On which page does the section start? __________.

2. The cabin pressure leakage checkout section gives maintenance personnel the instructions for pressure-testing the cabin after maintenance on the windshield, ______________________________ ______________________________.

3. No personnel shall be in the cabin when ______________ ______________________________.

4. ______________________________ shall remain stationed at the cabin leakage tester at all times while the cabin is being pressurized.

5. ______________________________ will be put on prior to pressurizing the cabin to ______________________.

6. The cabin pressure leakage checkout consists of ________ ______________________________.

7. What type of cabin leakage tester is used to make the checkout? ______________________________.

8. The leakage tester shall be placed at ______________ ______________________________ in direction away from the aircraft ______________________ area.

9. Cut the lockwire and remove the cap; then connect the canopy seal hose to ______________________ in the nose wheel well.

10. Take care when connecting the cabin leakage tester to the aircraft to prevent ______________________________.

11. ______________________ and remove the cap; then connect the air supply hose to ______________________.

12. How many hoses will be connected to the aircraft? ______________________.

13. Turn the dump valve on the leakage tester __________ to full ____________________ position.

14. Slowly turn ____________________ on the leakage tester ____________________ until a test pressure of ______________________ is shown on ________________.

15. Allow the system time to stabilize between __________ ______________________________ to avoid exceeding ____________________________________ at any time.

16. When the pressure rate-of-change gage reads zero cabin pressure should be stabilized at how much? ________________.

17. What does the abbreviation (scfm) mean? __________ ____.

18. New aircraft can have a leakage rate of ________ scfm. Leakage will ______________ as the aircraft is flown when ____; however, ________________________ ________________________ leakage of serviceable aircraft is less than ________ scfm.

19. If the cabin has too much leakage, which section of the TO refers to leakage repair? ________________________.

20. What substance should be used to find leaks during air pressure testing? ____.

21. Do not allow the rate of decrease in altitude to exceed ______________ ____________________ per minute.

22. The last step before you close and secure the forward equipment bay aft door is to ____________________ and lockwire.

Note: When you have done this part of the text, tell the instructor you are ready to make a pressure leakage test. He may have you wait for awhile until at least one other person is ready to make a test, since the job needs two people.

When the instructor gives you the OK to make a leakage test, do each of the steps in order.

1. Make sure that at least ONE person in your group has a copy of TO 1F-111A-2-2-1 and TO 33A4-4-10-1.

2. Go to room A-106 and tell the instructor that you are ready to make a leakage test. He will give you a toolbox.

Note: WORK AS A TEAM. Each of you make sure all steps are done PROPERLY and SAFELY.

3. The outside of both doors in room A-106 have folding yellow signs. UNFOLD and LATCH the signs so that outsiders will know that a pressurization check is in progress.

4. On the cabin trainer side facing the door of room A-106, you will see steps that are used to get in and out of the cockpit. To the right and below the steps, you will find two capped ports. One port is labeled CANOPY SEAL TEST and the other COCKPIT PRESSURE. About two feet to the right and just above these ports you will see a third port which is labeled CABIN LEAKAGE TEST. The Tester hoses will be connected to these three ports when you reach that point in the test. (NOT NOW)...

5. To the left of the steps is a white circuit breaker box. Behind and to the right of this box are two ports mounted on the cabin bulkhead. The cabin pressure regulator discharge port is labeled COMBAT and the schedule test port is labeled NORMAL.

Note: All five ports are in the nose wheel well on the aircraft.

6. Remove the vent caps and put an unvented test cap on the NORMAL port and one on the COMBAT discharge port, snug each cap gently with a wrench (the unvented test caps are kept in the toolbox). Read the NOTE in Section X, paragraph 10-18a, of TO 1F-111A-2-2-1, to understand why unvented test caps must be used. As far as we know, the F-111 is the only aircraft on which these ports are capped for leakage testing. On most planes a lever on the cabin pressure regulator is turned to shut off these ports.

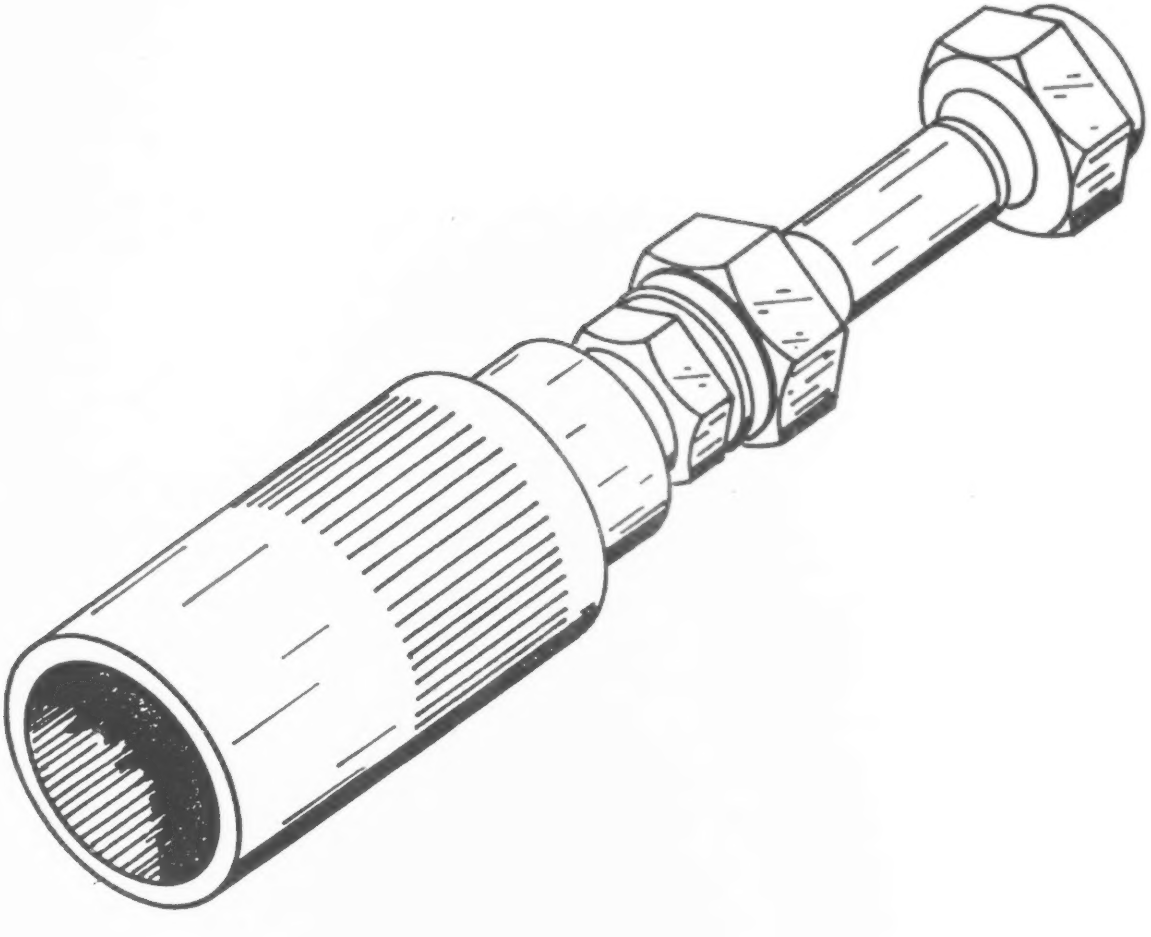


Figure 1. Hose Adapter.

7. Take the hose adapter (figure 1) from the toolbox and put it on the CABIN LEAKAGE TEST port. Do not lose the cap that you remove from this port. Tighten the adapter connection with a wrench; just tight enough so that it will not leak when the trainer cabin is pressurized.

8. Remove the hoses from the top of the tester cabinet.

9. Connect one end of the large cotton hose to the hose adapter on the trainer and the other end to the brass air outlet connection on the tester. Get two hose clamps from the toolbox and use them to secure the large hose so that it will not leak.

10. Connect the CANOPY SEAL hose to the tester and to the CANOPY SEAL TEST port on the trainer. Snug the fittings with a wrench.

11. Connect the CABIN PRESSURE hose to the tester and to the CABIN PRESSURE GAGE port on the trainer. Snug the fittings with a wrench.

> Note: The tester should be placed so that each hose is STRAIGHT and FLAT on the floor.

12. Close and latch both cabin hatches. CAUTION: MAKE SURE NO ONE HAS HIS HANDS IN THE WAY.

13. Place the SAFETY NET and secure it to the frame of the trainer. Make sure all glass areas are covered (the net should be placed so that it looks like that shown in figure 11-2 of TO 1F-111A-2-2-1). The single strap with a metal tab on it is placed on top and to the aft of the cabin. The metal tab fits over the head of the bolt at the rear of the cabin.

14. Connect the TESTER POWER cable to the 220V AC outlet, on the laboratory wall.

15. Open the instrument panel door. Open doors on the trainer, that TO 1F-111A-2-2-1 states should be open.

> Note: You have been taught how to operate the MB-3 cabin leakage tester. If you do not remember, read section IV of TO 33A4-4-10-1. Do not take chances...make sure you KNOW what you are to do. An operator must be at the cabin tester at all times while the cabin is pressurized. Decide among yourselves who the OPERATOR will be; HE IS THE ONE THAT WILL OPERATE THE TESTER.

16. Turn the DUMP VALVE to full open.

17. Turn the canopy seal air regulator counterclockwise until the control feels slightly loose.

18. Turn the CABIN PRESSURE ADJUSTMENT knob COUNTERCLOCKWISE until a minimum pressure of 2 psi shows on the regulator dial.

19. Everyone put on a headset and plug it into one of the intercom jacks. The jacks are on the white power box at the front of the trainer. Use the headset when you want to talk with the instructor and the other students.

Caution: Do not unlatch the hatches while the cabin is pressurized.

20. Push the start button to start the tester.

21. Slowly adjust the CANOPY SEAL AIR REGULATOR until 50 to 60 psi shows on the CANOPY SEAL PRESSURE GAGE. The canopy seal will inflate and stop leakage from around the canopy hatches.

22. Slowly turn the tester DUMP VALVE CLOCKWISE to the full closed position. Air will flow to pressurize the cabin.

Caution: Watch the pressure RATE OF CHANGE gage to make sure you DO NOT cause more than a 5000 feet-per-minute altitude increase at ANY time.

23. Slowly turn the PRESSURE ADJUSTMENT knob on the tester CLOCKWISE while closely watching the CABIN PRESSURE gage and the RATE OF CLIMB indicator.

Note: Blower pressure will be a little more than cabin pressure, due to normal leakage from the crew module. Pressurize the trainer to 5.0 psi so blower pressure is held just high enough to keep cabin pressure at 5.0 psi.

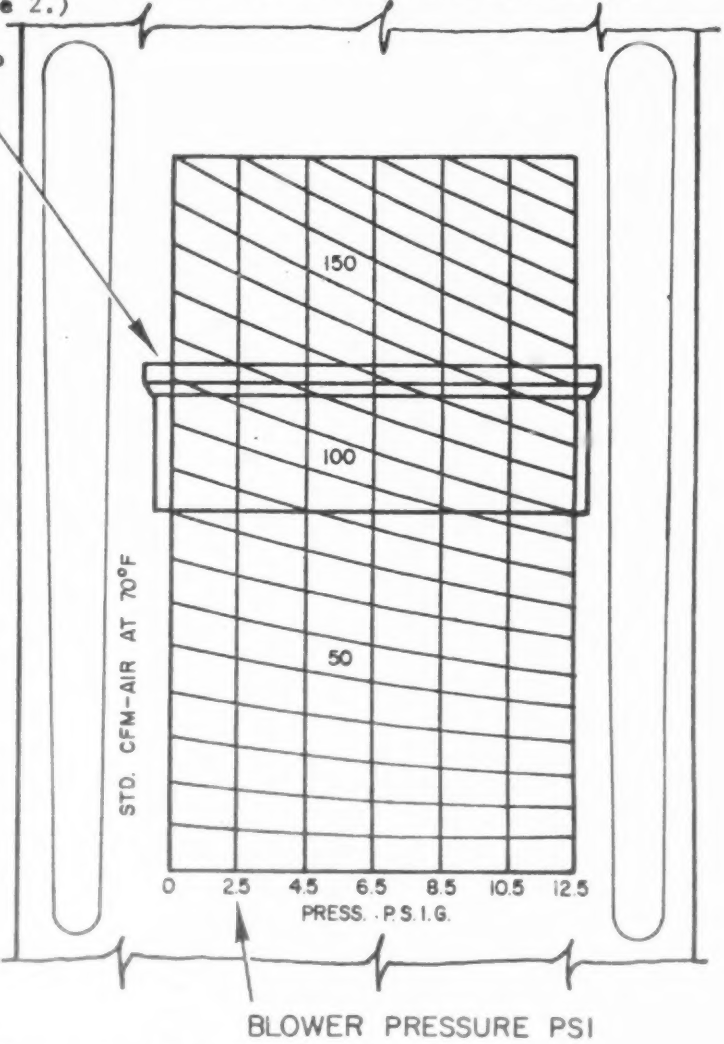
24. Do not let the temperature of the air that flows to the cabin be more than 49°C (120°F). If this happens it means there is something wrong with the cabin tester blower and the tester should be shut down.

25. When the PRESSURE RATE OF CHANGE gage starts to show a rise in cabin pressure, adjust the tester for the maximum pressure rise a 5000 feet-per-minute altitude change would need. This is done by slowly turning the pressure adjustment CLOCKWISE by 1/16 of a turn. Do this until the desired rate of increase is shown.

26. When cabin pressure is stabilized at 5.0 psi and the PRESSURE RATE OF CHANGE gage reads ZERO, find the rate of cabin leakage as follows:

a. Read blower pressure as shown on the BLOWER PRESSURE gage.

b. Find the point on the tester FLOWMETER SCALE where the vertical line (shows blower pressure) cuts the top edge of the flowmeter float (figure 2.)


READ FLOW AT TOP EDGE OF FLOAT
150
100
50
STD. CFM-AIR AT 70°F
0
2.5
4.5
6.5
8.5
10.5
12.5
PRESS. - P.S.I.G.
BLOWER PRESSURE PSI

Float at position shown indicates the following free air flow at the various blower pressure readings

Press. PSI		Flow CFM
0	---	118
2.5	---	124
4.5	---	130
6.5	---	137
7.5	---	140
8.5	---	144
10.5	---	150
12.5	---	158

Figure 2. MB-3 Flowmeter.

c. If the point is EXACTLY on the diagonal line, read the flow (cabin leakage rate) in standard cubic feet per minute (scfm).

d. If the point is BETWEEN TWO DIAGONAL LINES, guess the distance above the lower line and add this to the value of that lower line.

e. If leakage is more than 68.0 scfm, turn to the AIR PRESSURE LEAKAGE REPAIR section of TO 1F-111A-2-2-1, for repair instructions.

> Note: If the trainer cabin has too much of a leak, the leak would not be repaired. The class period is not long enough for the job.

f. If flow (cabin leakage rate) on the flowmeter is less than 68.0 scfm (5.2 pounds-per-minute), start the SHUTDOWN steps.

SHUTDOWN STEPS

1. Slowly turn the PRESSURE ADJUSTMENT knob COUNTERCLOCKWISE to minimum.

2. Slowly open the DUMP VALVE. CAUTION: Do not allow the rate of decrease in altitude to be more than 5000 feet-per minute.

3. When cabin pressure has dropped to 1.0 psi, take the unvented test caps from the COMBAT and NORMAL discharge ports and install the VENTED caps.

4. Turn the CANOPY SEAL AIR REGULATOR knob COUNTERCLOCKWISE to release pressure from the canopy seals.

Note: When the cap is removed from the NORMAL port, the 1.0 psi will vent to zero. There will not be enough pressure to cause injury or damage.

5. Push the OFF button to stop the leakage tester.

6. Unplug, remove, and stow the headsets.

7. Disconnect each hose from the tester and trainer. Stow them in the top of the tester.

8. Disconnect the tester power cable and stow it inside the tester.

9. Place caps on all ports.

10. Place the hose adapter, clamps, and handtools in the toolbox and lock it.

11. Remove and stow the safety net.

12. Open both of the cabin hatches.

13. Fold the warning signs on the outside of the classroom doors.

Note: While the cabin tester is still handy, let us talk about the flowmeter for just a minute. You can use the flowmeter to measure cabin leakage if the temperature of the air that flows through the meter is 70°F. If the air temperature is more or less than 70°F, or if the cabin leakage has to be changed from scfm to pounds-per-minute (as some aircraft TOs require), refer to TO 33A4-4-10-1, paragraph 4-9 and/or 4-10 for the correct method of figuring cabin leakage.

14. Return the TOs to the proper file cabinet.

15. Tell the instructor that you have completed the cabin pressure leakage check and he will initial your forms (that is if you did all parts of the check properly). Return to the classroom and review for the measurement.

Assists: 1. ________ 2. ________ 3. ________

Instructor's Signature ____________________

SERVICE TEST
PROGRAMMED TEXT
C3ABR42331-PT-401

Technical Training

Aircraft Environmental Systems Mechanic

AIRCRAFT GASEOUS OXYGEN SYSTEMS SAFETY AND INSPECTION

31 May 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

OBJECTIVES

1. Specify, without error, general principles relating to oxygen systems safety.

2. State general principles relating to the inspection of gaseous oxygen systems.

INSTRUCTIONS

This programmed text presents material in small steps called "frames." The material contained herein is in support of the lessons presented in class by the instructor. After some of the frames you will find a number of statements that you are asked to select the statements that are true. Read the material in each frame before making a selection. The answers to each frame can be found on the following page. If you select the correct answers, continue to the next frame. If you select the wrong answer or are in doubt, read the material again and correct yourself before proceeding.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Frame 1

One of the most important safety factors that you should know about oxygen is that it makes other materials burn rapidly. This characteristic, along with the fact that oxygen is handled under pressure, sometimes as high as 2,000 psi, gives just cause for following strict rules for oxygen when working around it.

NO RESPONSE NECESSARY

1156

Frame 2

Keep oil and grease away from oxygen and oxygen equipment. Oil, grease, and oxygen DO NOT MIX, and an explosion may result from their mixing.

Select the following statements that are true.

_____1. Grease may be used to lubricate oxygen fittings.

_____2. Oil and grease should be kept away from oxygen equipment.

Answers to Frame 2: _F_ 1. _T_ 2.

Frame 3

When using a thread lubricant for pipe thread fittings on oxygen equipment, use an approved tetrafluroethylene (teflon) tape. This tape is the only type of lubricant that can be used on oxygen fittings.

NO RESPONSE NECESSARY

Do not allow sparks or high temperatures near oxygen. Oxygen supports combustion. There is no need to help a fire or explosion get started. DO NOT smoke near oxygen or oxygen equipment. The minimum safe distance you may smoke is 50 feet.

Select the statements that are TRUE.

_____1. Sparks or high temperatures around oxygen may result in an explosion.

_____2. 75 feet is the minimum safe distance you can be when smoking.

Answers to Frame 4: T 1. F 2.

Frame 5

Handle charged cylinders with care. Protect stored oxygen cylinders from excessive heat.

NO RESPONSE NECESSARY

Frame 6

Never mix oxygen with other gases. Never store oxygen cylinders in the same area as other gases. Keep them separate.

NO RESPONSE NECESSARY

1160

Frame 7

Do not service, purge or drain an aircraft oxygen system within 50 feet of hangars or other structures. If, by chance, an explosion did occur, we want to lessen the damage as much as possible.

NO RESPONSE NECESSARY

Frame 8

Drain the system prior to removing lines; install protective caps and seals in opened lines to prevent the entrance of foreign material.

NO RESPONSE NECESSARY

Frame 9

Use only AVIATOR'S breathing oxygen specification MIL-O-27210 Type 1, for servicing or purging aircraft systems.

NO RESPONSE NECESSARY

Frame 10

If the system has been left open or has been empty, purge the system.

Select the statements concerning oxygen system safety that are TRUE.

_____1. Oxygen systems must be kept free of grease and oils.

_____2. An oxygen system must be purged if it has been left open.

_____3. Protective caps or plugs must be installed in the lines when an oxygen system is opened.

_____4. Only aviator's or hospital oxygen may be used in aircraft oxygen systems.

_____5. Oxygen supports combustion.

Answers to Frame 10: __T__ 1. __T__ 2. __T__ 3. __F__ 4.
__T__ 5.

Frame 11

Now we are going to take a look at inspection requirements for gaseous oxygen systems. The oxygen system is normally inspected during the scheduled phase or periodic inspection.

NO RESPONSE NECESSARY

Frame 12

Cylinders and plumbing should be checked closely for corrosion, dents, cracks, and proper support. Corrosion is especially noticable around tubing sleeves and B nuts. It also appears under support clamps and there it is usually hard to detect because it is covered by the clamp.

NO RESPONSE NECESSARY

Frame 13

Regulator to mask hoses should be checked for chaffing, collapsing, kinking, and proper length and routing.

Contamination of hoses with any solvents or paint sprays will cause an odor. The hoses should be replaced if any of these defects are found.

NO RESPONSE NECESSARY

Frame 14

The regulators are usually checked with one of the regulator testers such as the oxygen regulator field tester; there are others. The regulator to mask hose quick disconnect must be checked with a go-no-go gage. This test should be performed at every scheduled inspection or whenever it is suspected that the quick disconnect is worn.

Select the statements concerning gaseous oxygen inspections that are TRUE.

_____1. Cylinders and plumbing should be checked for proper support.

_____2. Corrosion usually appears on the tubing itself.

_____3. If a mask to regulator hose gives evidence of an odor, it should be replaced.

_____4. The go-no-go gage inspection should be performed during home station checks.

_____5. Regulators will be tested using the go-no-go gage.

Answers to Frame 14: __T__ 1. __F__ 2. __T__ 3. __F__ 4.
__F__ 5.

PROGRAMMED TEXT

3ABR42331-PT-401A

Technical Training

Aircraft Environmental Systems Repairman

LOW AND HIGH-PRESSURE GASEOUS OXYGEN SYSTEMS

23 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: [redacted]9.7

OBJECTIVE

Relate four of five low and high pressure gaseous oxygen system components to their operation.

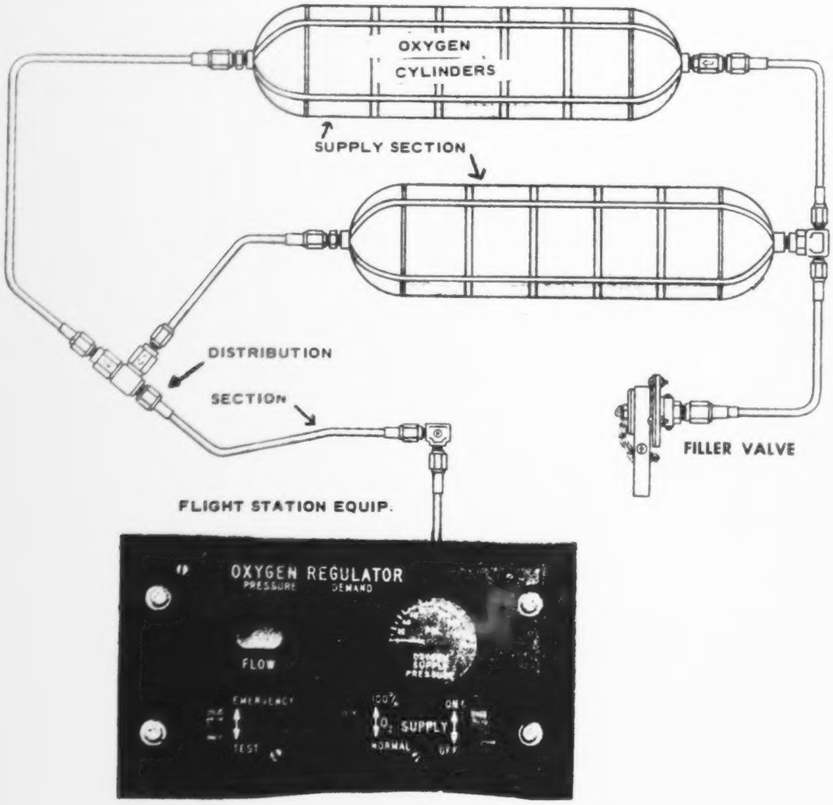
INSTRUCTIONS

This programmed text presents material in small steps called "frames." After each step you are asked to select the correct statement or match some statements. Read the material presented and make your response as directed in the frame. The correct answer to each frame can be found on the top of the next page. If your answer is correct proceed to the next frame; if you are wrong or in doubt, read the material again and correct yourself before continuing.

Supersedes 3ABR42231-PT-401A, 10 February 1976.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; DAV - 1

Frame 1

Many types of oxygen systems are used on aircraft. A system consists of two sections: the supply or storage section with its connecting plumbing, and the distribution section which includes the regulators. The type of system used in a given aircraft is determined by the type of regulator that is used. Oxygen regulators are grouped into three types: demand, pressure demand, and continuous flow. Any of the three types of regulators can be used with any type of supply system. The types of supply systems are low and high pressure gaseous oxygen, and low and high pressure liquid oxygen.


OXYGEN CYLINDERS
SUPPLY SECTION
DISTRIBUTION SECTION
FILLER VALVE
FLIGHT STATION EQUIP.
OXYGEN REGULATOR
PRESSURE DEMAND
FLOW
EMERGENCY
TEST
100% O2
NORMAL
SUPPLY
ON
OFF

Check the following statement/s that are true.

_____1. The type of oxygen system is determined by the regulator used.

_____2. Any of the three types of regulators can be used with any of the supply systems.

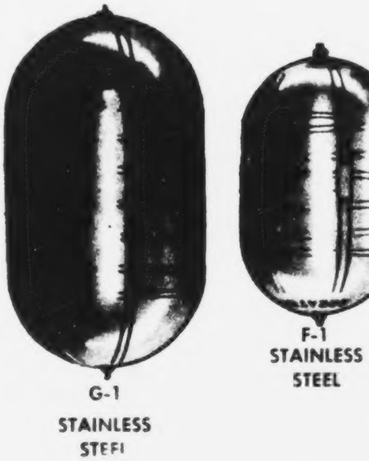
_____3. Normally there are five sections in an oxygen system.

_____4. The three types of regulators are demand, pressure demand, and continuous flow.

Answers to Frame 1: ✓ 1. ✓ 2. _____3. ✓ 4.

Frame 2

The low pressure gaseous oxygen system is used on the old type transport and cargo aircraft. The cylinders are mounted with straps in sections of the aircraft where space is available. They carry a maximum charge of 450 psi and are considered to be full between 400 and 450 psi. The pressure should not be allowed to drop below 50 psi. This is to prevent contamination of the cylinder due to moisture that will accumulate in the cylinder. Low pressure cylinders are made shatterproof by welding metal bands to the outer side. The cylinders are made of stainless steel or a low alloy steel and are painted yellow to identify them as low pressure.



Typical Low-Pressure Cylinders (Painted Yellow)

Check the following statement/s that are true.

_____1. All low pressure cylinders are painted yellow.

_____2. Maximum service pressure for low pressure cylinders is 450 psi.

_____3. At least 50 psi should always be left in the cylinders.

_____4. Low pressure cylinders are not shatterproof.

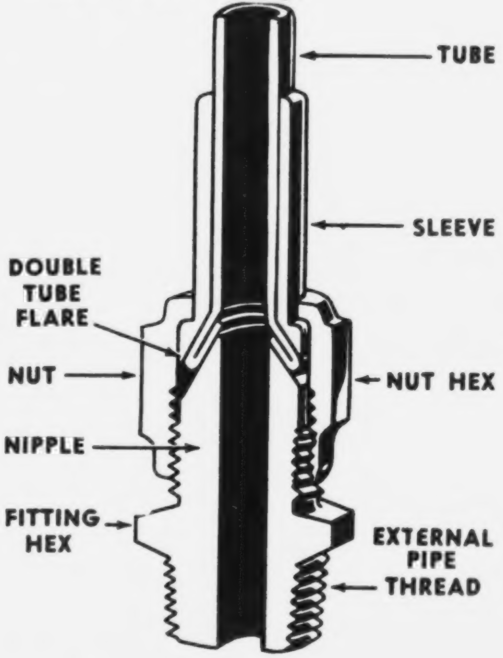
_____5. Low pressure cylinders are considered full at 400 psi.

Answers to Frame 2: __✓__1. __✓__2. __✓__3. _____4. __✓__5.

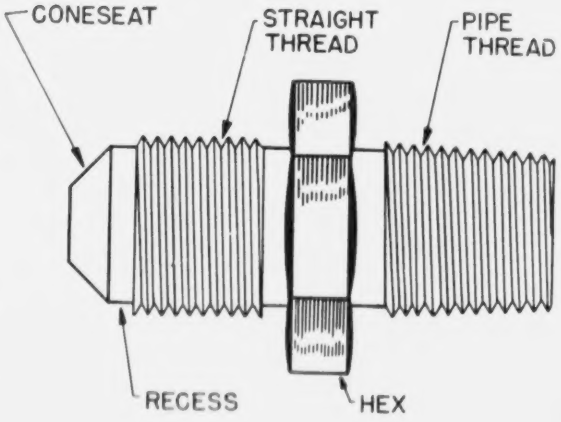
Frame 3

Low pressure systems use 5/16-inch aluminum tubing. The tubing used in all oxygen systems has the size numbered in 1/16-inch increments. A number 5 tubing has an outer diameter of 5/16-inch, a number 3 would be 3/16-inch, etc. All tubing carrying oxygen is color coded with green tape to distinguish it from other tubing in the aircraft. During manufacture the tubing used is heat treated for strength and treated also to prevent corrosion. Two kinds of connections are used in oxygen systems: flared tube connections, and pipe thread connections.

The fittings used in low pressure systems are made of aluminum alloy and painted blue to identify the material. These are "AN" standard (Army-Navy) fittings. The pipe thread end of the fitting screws into cylinders, regulators, and gages. The coneseat end connects the flared tubing.


TUBE
SLEEVE
DOUBLE TUBE FLARE
NUT
NUT HEX
NIPPLE
FITTING HEX
EXTERNAL PIPE THREAD

Double Flared Connection


CONESEAT
STRAIGHT THREAD
PIPE THREAD
RECESS
HEX

AN Standard Fitting (Painted Blue)

Check the following statement/s that are true.

_____1. If you asked for a piece of number 5 tubing, you would get 5/16.

_____2. Low pressure systems use number 5 aluminum tubing.

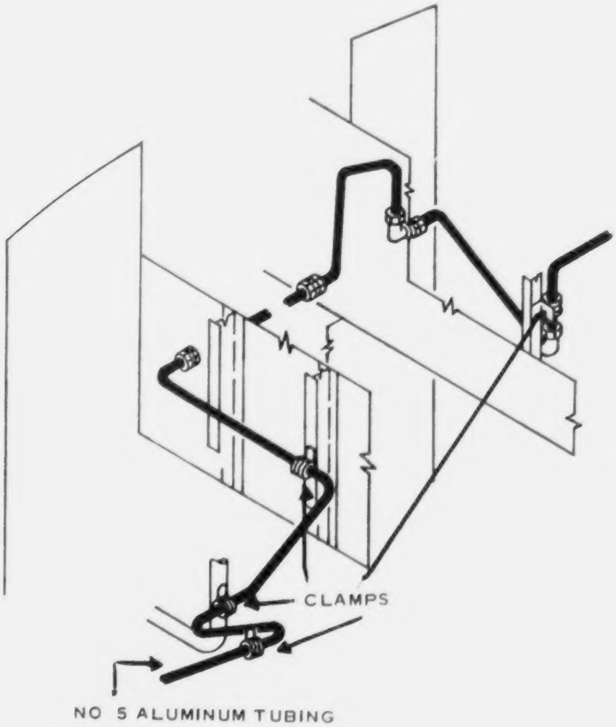
_____3. The flared tubing is connected to the pipe thread fitting.

_____4. All tubing carrying oxygen is color coded green.

Answers to Frame 3: __√__1. __√__2. __√__3. __√__4.

Frame 4

The tubing is braced with clamps every 15 inches apart and at each bend all through the aircraft. This helps to reduce tubing vibration and also helps to prevent chafing of the tubing. Oxygen tubing should be installed with at least a two-inch clearance between electrical wiring or any control cables. The tubing is bent when necessary to insure that this clearance is maintained. The tubing may run within 1/2-inch of electrical wiring so long as more insulation is used on the wires, but this is the absolute minimum.



Check the following statement/s that are true.

_____1. Tubing should be clamped every 15 inches and at each bend.

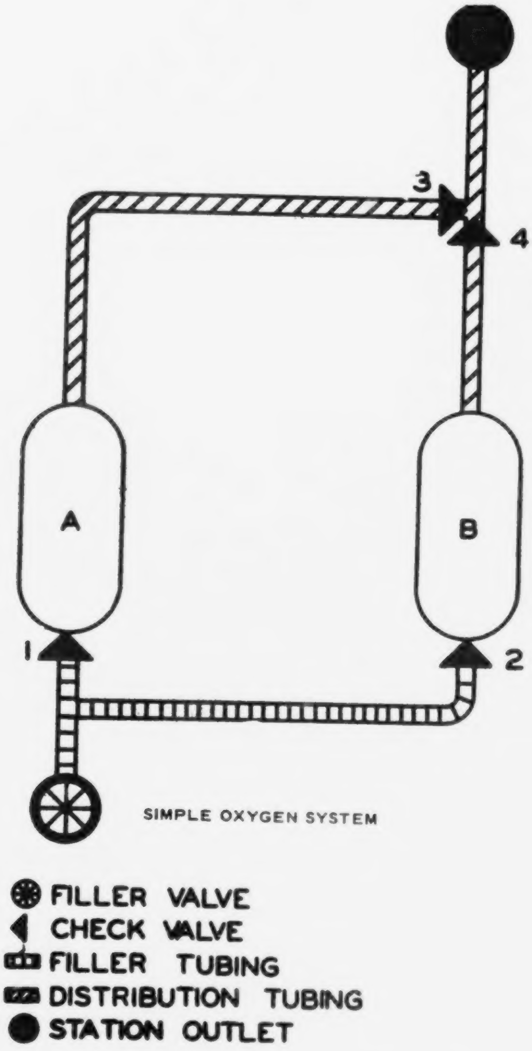
_____2. A two-inch clearance should be maintained between tubing and electrical wires and control cables.

_____3. 1/2-inch is the absolute minimum clearance on oxygen tubing.

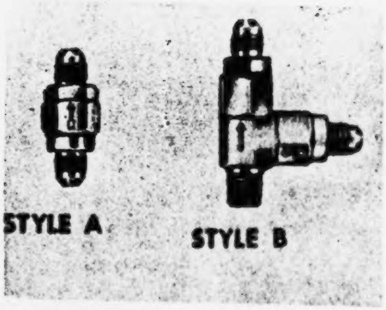
Answers to Frame 4: __√__1. __√__2. __√__3.

Frame 5

Check valves are used in oxygen systems that have more than one cylinder. A check valve helps to prevent a complete loss of oxygen if part of the system is damaged. Check valves may be in many styles to meet the need of the installation. An arrow on the side of the check valve shows the direction of free flow. If cylinder "A", in the illustration, ruptured, the oxygen in cylinder "B" would not go out through the hole because of check valve number 3. Check valves must be installed so that all cylinders can be filled from a single filler valve, all cylinders will feed the regulator, and if one cylinder ruptures, the other cylinders will not drain out through it.



SIMPLE OXYGEN SYSTEM



Check the following statement/s that are true.

_____1. The arrow on a check valve indicates direction of free flow.

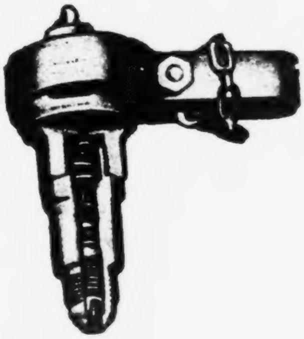
_____2. Check valves are not required if more than one cylinder is used.

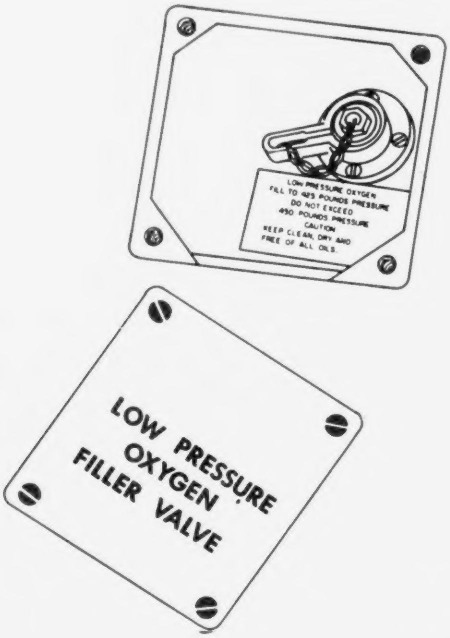
_____3. Check valves are installed so that all cylinders can be filled from one valve.

Answers to Frame 5: ✓ 1. ____2. ✓ 3.

Frame 6

Filler valves are used when filling the oxygen system. They are usually mounted near the outer surface of the aircraft in a recessed well and under an access cover. Each filler valve has a dust plug attached to the valve by a chain. The plug can be removed by turning the handle. When the dust plug is removed, a recharge adapter on the servicing hose is put in the filler valve to fill the system. The filler valve is nothing more than a spring loaded check valve that is unseated by the recharge adapter and seats when the adapter is removed.




LOW PRESSURE OXYGEN
FILL TO 425 POUNDS PRESSURE
DO NOT EXCEED
490 POUNDS PRESSURE
CAUTION
KEEP CLEAN, DRY AND
FREE OF ALL OILS.
LOW PRESSURE
OXYGEN
FILLER VALVE

Check the following statement/s that are true.

____1. A filler valve is a spring loaded check valve.

____2. The recharge adapter unseats the filler valve.

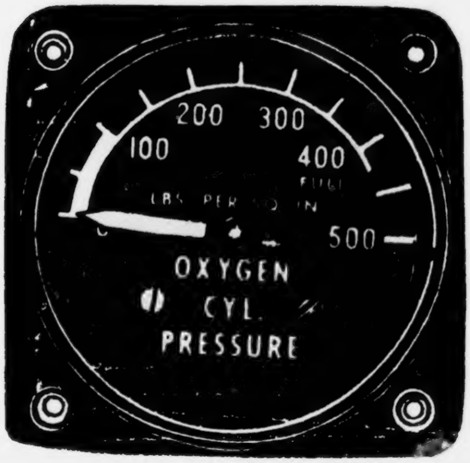
____3. The filler valve is located on the outer surface of the aircraft.

____4. A wrench is required to connect the recharge adapter.

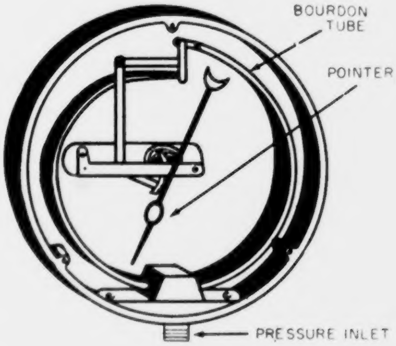
Answers to Frame 6: ___✓___1. ___✓___2. ___✓___3. _____4.

Frame 7

A separate gage may be used in some low pressure oxygen systems to show cylinder or system pressure. This will depend on the type of regulator that is used. Some regulators have a pressure gage built in them. One of the indicators used is the K-1 bourdon tube-operated type. The bourdon tube is hollow and in the shape of a "C." Pressure put on the inside of the tube will try to straighten it out. The pointer is linked through levers to the bourdon tube. The dial face is marked off in 50 psi graduations and the 0-100 psi range is lined out to attract attention to these pressure readings. Most gages have a red mark on the glass cover at 450 psi to point out the maximum service pressure. The gage is found in the cockpit in a readily visible location.



K-1 Pressure Gage



Check the following statement/s that are true.

_____1. The K-1 pressure gage is bourdon tube-operated.

_____2. Some regulators have a pressure gage built in.

_____3. The K-1 pressure gage is electrically operated.

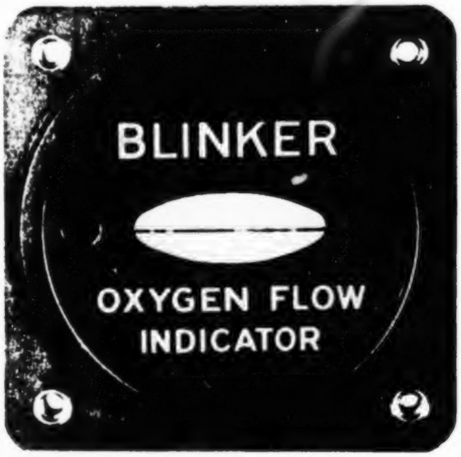
_____4. The pointer is connected through levers to the bourdon tube.

_____5. Pressure in the hollow bourdon tube tends to straighten it out and deflects the needle.

Answers to Frame 7: ___✓___1. ___✓___2. ______3. ___✓___4. ___✓___5.

Frame 8

A separate flow indicator is used in some low pressure oxygen systems to show that oxygen is flowing through the regulator. Some regulators have a flow indicator built in them. The A-3 flow indicator is the type used as a separate flow indicator. The A-3 indicates by a blinking action when the user inhales through the oxygen mask. The blinker "eye" is actuated by a diaphragm in the unit. The flow indicator does not show how much oxygen is flowing or that the user is getting enough oxygen, it just tells the user that he is receiving a flow.



A-3 Flow Indicator

Check the following statement/s that are true.

______1. The A-3 indicates oxygen flow through the regulator.

______2. "Blinker" is the correct name for the A-3.

______3. The blinker eye operates from a diaphragm.

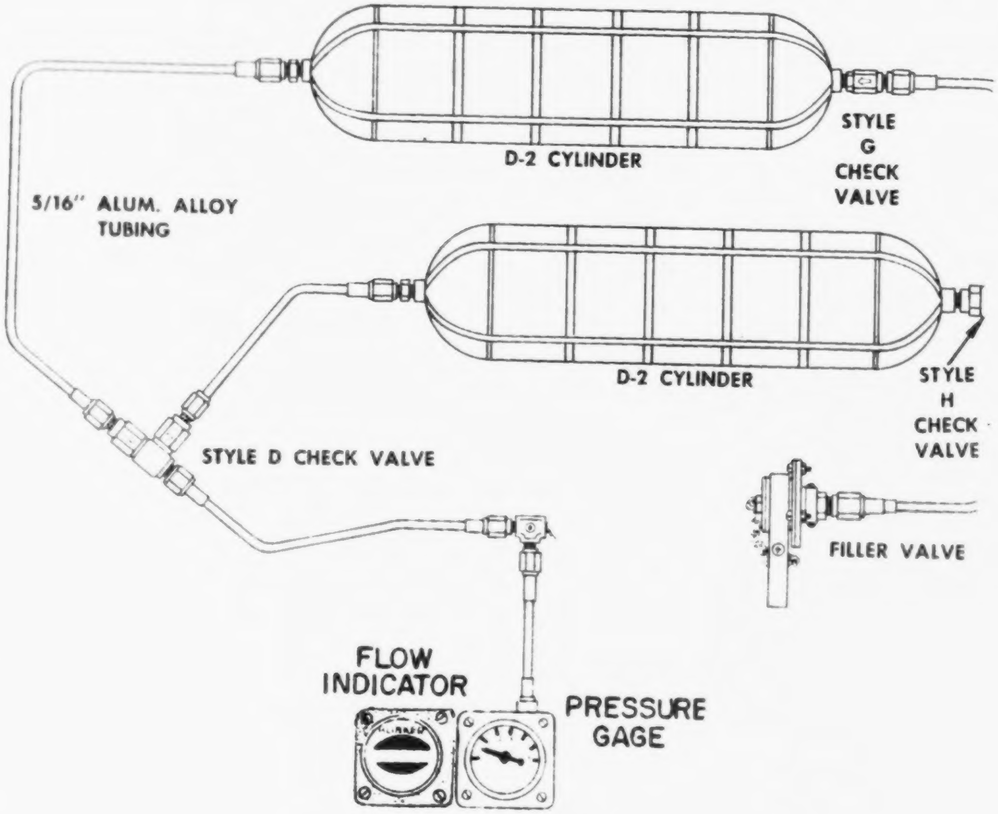
______4. Some regulators have a built in flow indicator.

______5. The A-3 does not indicate the amount of oxygen flowing.

Answers to Frame 8: ✓ 1. ___ 2. ✓ 3. ✓ 4. ✓ 5.

Frame 9

Shown is a low pressure oxygen system with all the units that have been covered in the text. This system uses the D-2 shatterproof cylinder, various style check valves, number 5 aluminum tubing, low pressure filler valve, flow indicator, and pressure gage. The size and amount of cylinders used depends upon the need of the particular aircraft that the system is used on.


D-2 CYLINDER
STYLE G CHECK VALVE
5/16" ALUM. ALLOY TUBING
D-2 CYLINDER
STYLE H CHECK VALVE
STYLE D CHECK VALVE
FILLER VALVE
FLOW INDICATOR
PRESSURE GAGE

NO RESPONSE REQUIRED

Answer to Frame 9: None Required.

Frame 10

The high pressure oxygen system has the same principle of operation as the low pressure system. Its one advantage is that more oxygen can be stored in a smaller space; however, the oxygen is stored at a high pressure (1,800 psi). The same maintenance procedures and safety rules apply to both the high and low pressure oxygen systems. Care must be taken when opening lines in a high pressure system. Make sure they have been drained to prevent possible body damage from the high pressure. High pressure gaseous oxygen systems are not widely used, but they will be your responsibility.

Check the following statement/s that are true.

_____1. More oxygen can be stored in a smaller space using a high pressure system.

_____2. High pressure oxygen is particularly dangerous.

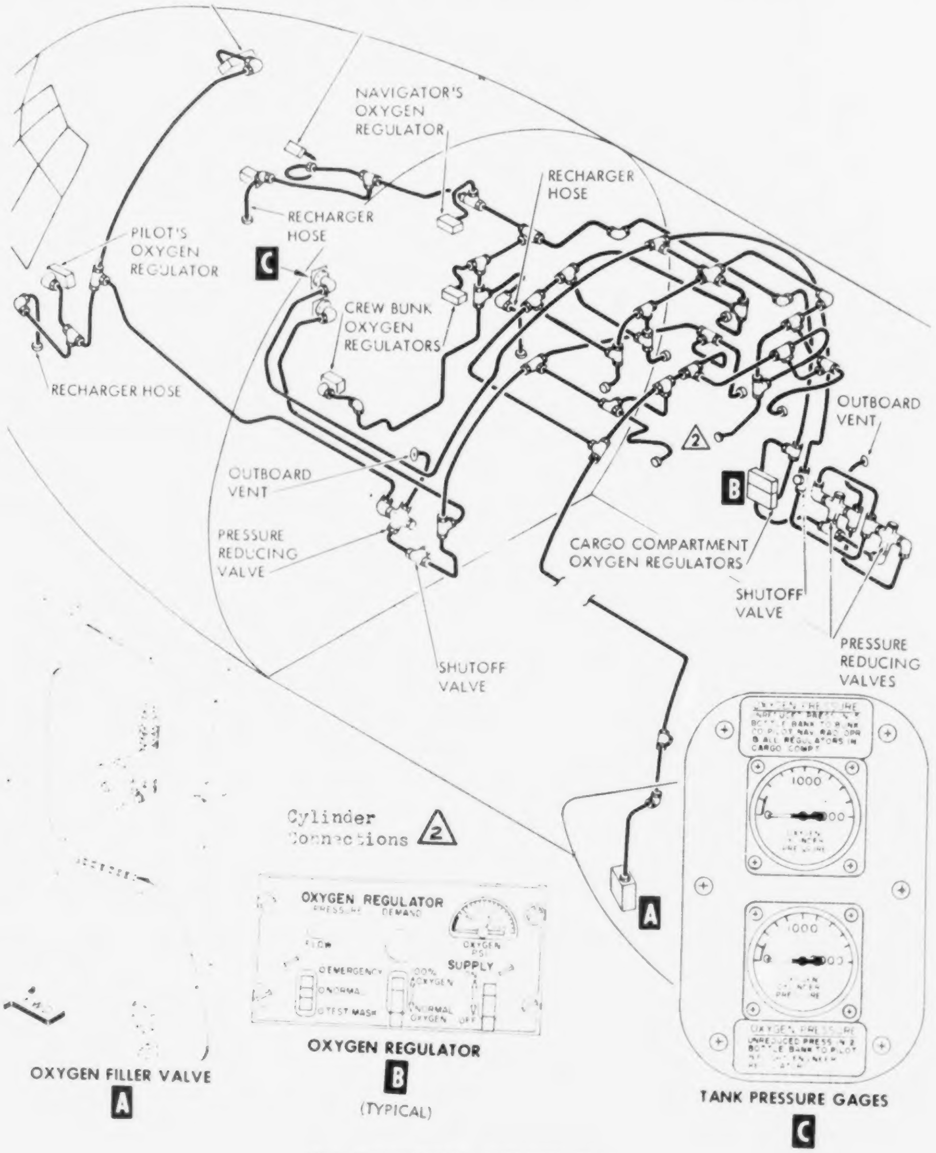
_____3. High pressure oxygen systems are widely used.

_____4. In general, the same safety precautions apply to low and high pressure systems.

Answers to Frame 10: ✓ 1. ✓ 2. ____3. ✓ 4.

Frame 11

Find these listed units in the illustration shown: the high pressure filler valve, the pressure reducing valves, the system shutoff valves, the pressure gages, and the cylinder connection points. The check valves, which are not shown, are the next items in the plumbing. These items and the plumbing will be covered in this text.

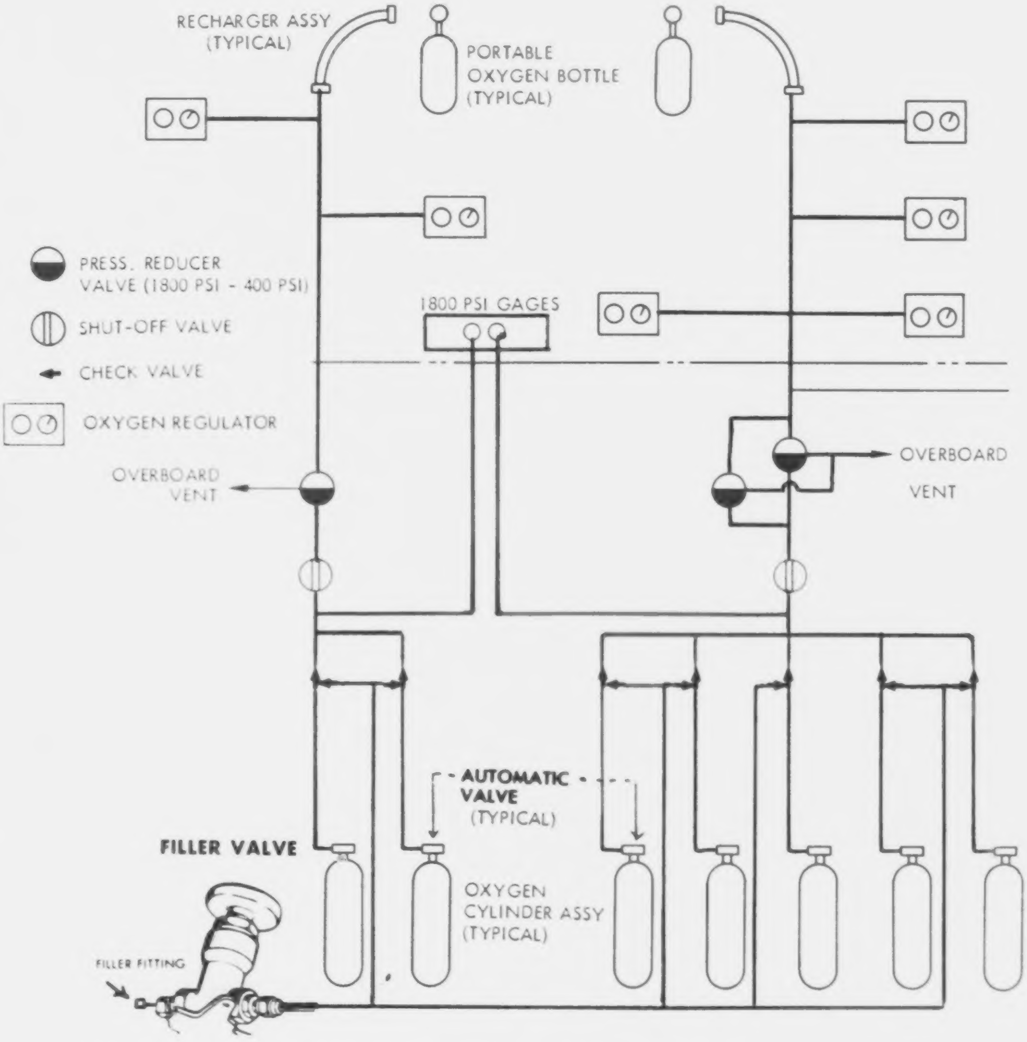

NAVIGATOR'S OXYGEN REGULATOR
RECHARGER HOSE
RECHARGER HOSE
PILOT'S OXYGEN REGULATOR
C
CREW BUNK OXYGEN REGULATORS
RECHARGER HOSE
OUTBOARD VENT
2
OUTBOARD VENT
B
PRESSURE REDUCING VALVE
CARGO COMPARTMENT OXYGEN REGULATORS
SHUTOFF VALVE
SHUTOFF VALVE
PRESSURE REDUCING VALVES
Cylinder Connections 2
A
OXYGEN REGULATOR
PRESSURE DEMAND
FLOW
EMERGENCY
NORMAL
TEST MASK
100% OXYGEN
NORMAL OXYGEN
OXYGEN PSI
SUPPLY
ON
OFF
1000
1000
OXYGEN PRESSURE
OXYGEN PRESSURE
OXYGEN FILLER VALVE
A
OXYGEN REGULATOR
B
(TYPICAL)
TANK PRESSURE GAGES
C

NO RESPONSE REQUIRED

Answer to Frame 11: None Required.

Frame 12

Study this simplified diagram of the same system that was given in the last frame. Note the two separate systems. The two cylinders shown on the lift side of the system supply the oxygen to the regulators on that side. The left side has its own system shutoff valve pressure reducer valve, and cylinder pressure gage. The right side has two pressure reducing valves that are hooked in parallel. The cylinders for both sides are filled from a common filler valve.


RECHARGER ASSY (TYPICAL)
PORTABLE OXYGEN BOTTLE (TYPICAL)
PRESS. REDUCER VALVE (1800 PSI - 400 PSI)
SHUT-OFF VALVE
CHECK VALVE
OXYGEN REGULATOR
1800 PSI GAGES
OVERBOARD VENT
OVERBOARD VENT
AUTOMATIC VALVE (TYPICAL)
FILLER VALVE
FILLER FITTING
OXYGEN CYLINDER ASSY (TYPICAL)

Check the following statement/s that are true.

_____1. In the schematic shown, there are two separate high pressure systems.

_____2. All cylinders are filled from a common filler valve.

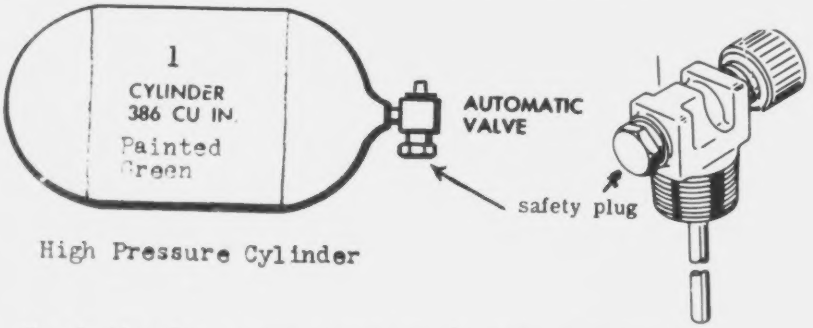
_____3. The components are completely different in each system.

_____4. The right hand side has two pressure reducing valves in parallel.

Answers to Frame 12: __✓__ 1. __✓__ 2. _____ 3. __✓__ 4.

Frame 13

The high pressure oxygen cylinders are made of forged seamless steel and are wire-wrapped to make them shatterproof. The service pressure for the cylinders is from 1,800 to 1,850 psi. These high pressure cylinders are painted green. An automatic valve is put on the release end of the cylinder to let the cylinder be removed without discharging, for maintenance on the system. A fusible safety plug is in the automatic valve to dump pressure if the temperature gets between 208° and 220°F. A hydrostatic test is required on these high pressure cylinders every five years to determine their condition. The test date is stamped on the neck of the cylinder.



High Pressure Cylinder

Check the following statement/s that are true.

_____1. 1,850 psi would be the maximum service pressure.

_____2. High pressure cylinders are wire-wrapped to make them shatterproof.

_____3. All high pressure cylinders are painted green.

_____4. The automatic valve allows the cylinder to be removed without discharging.

_____5. A fusible plug is built into the automatic valve.

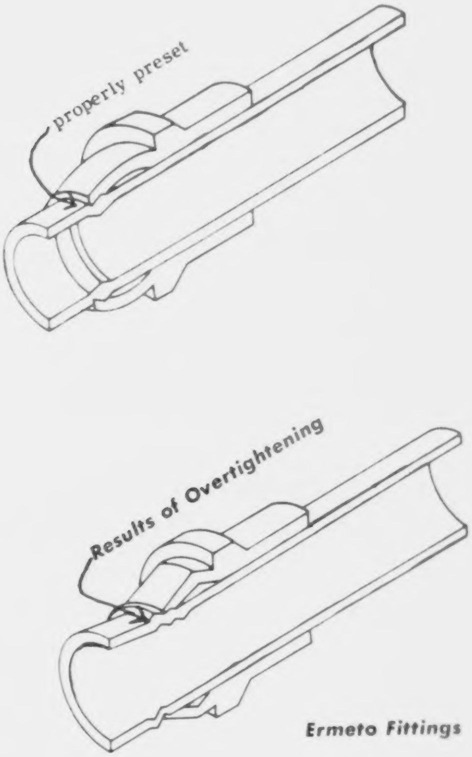
_____6. The high pressure cylinders are made of aluminum.

_____7. The fusible safety plug will melt at a temperature of 208° to 220°F.

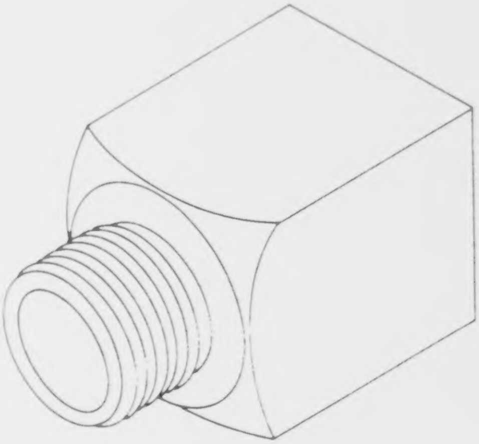
Answers to Frame 13: ✓ 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5.
_____6. ✓ 7.

Frame 14

The tubing used in high pressure gaseous oxygen systems is either 3/16-inch or 5/16-inch stainless steel. Aluminum tubing will not stand the high pressure. The high pressure stainless steel tubing requires a flareless type fitting called Ermeto fitting. The fitting consists of a sleeve which is preset on the end of the tubing before the tubing is put in a flareless seat. If you overtighten an Ermeto fitting while trying to stop a leak, it usually will leak more. A torque wrench should always be used.



Ermeto Fittings



Hand Presetting Tool

Check the following statement/s that are true.

_____1. High pressure systems use stainless steel tubing.

_____2. Ermeto fittings are flareless fittings.

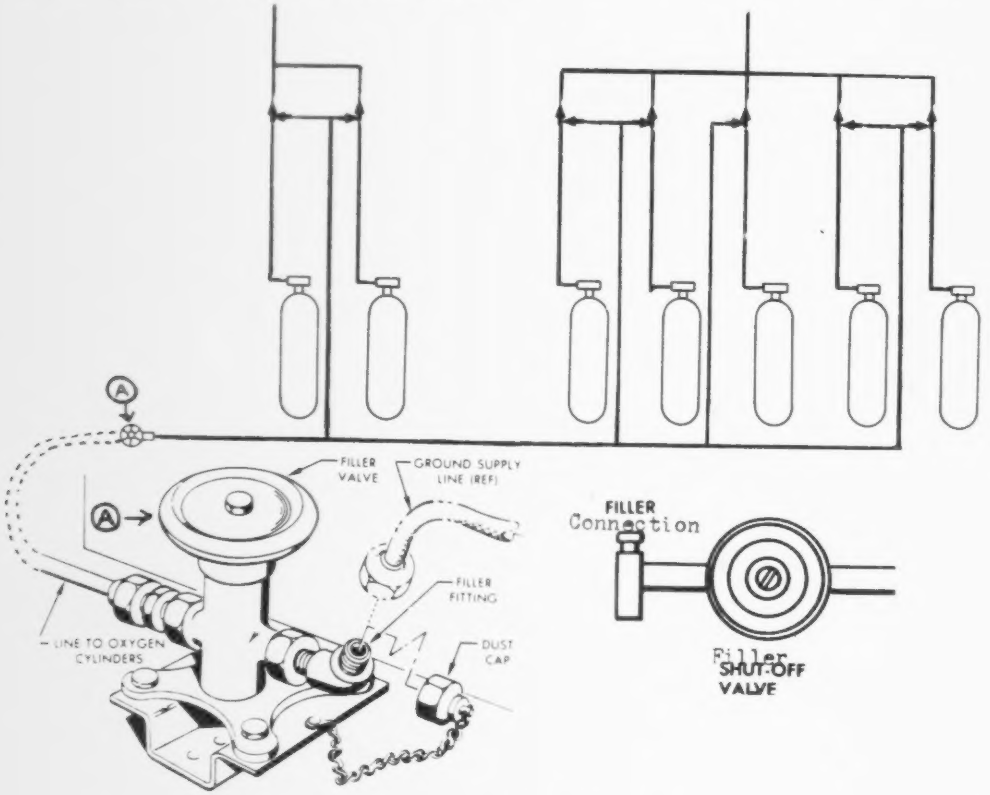
_____3. You can stop an Ermeto fitting from leaking by increasing the torque.

_____4. A torque wrench should always be used on an Ermeto fitting.

Answers to Frame 14: ___✓___1. ___✓___2. ______3. ___✓___4.

Frame 15

The high pressure filler valve is hand wheel operated and separates the filler connection from the cylinders. This valve must be open when the system is filled with oxygen and is closed at all other times. The filler connection is used to hook the rcharging equipment to the aircraft system. The type of filler valve connection shown in one illustration is flange mounted to the aircraft and in the other it is part of the valve. Because of the high pressure used quick disconnects are not used when the system is recharged. The system check valves serve the same purpose as in the low pressure oxygen system, but are made to stand higher pressures. Remember, check valves stop a reverse flow.


A
FILLER VALVE
GROUND SUPPLY LINE (REF)
A →
FILLER FITTING
DUST CAP
LINE TO OXYGEN CYLINDERS
FILLER Connection
Filler SHUT-OFF VALVE

Check the following statement/s that are true.

_____1. The filler valve is opened only for filling the system.

_____2. Quick disconnects are used when recharging high pressure systems.

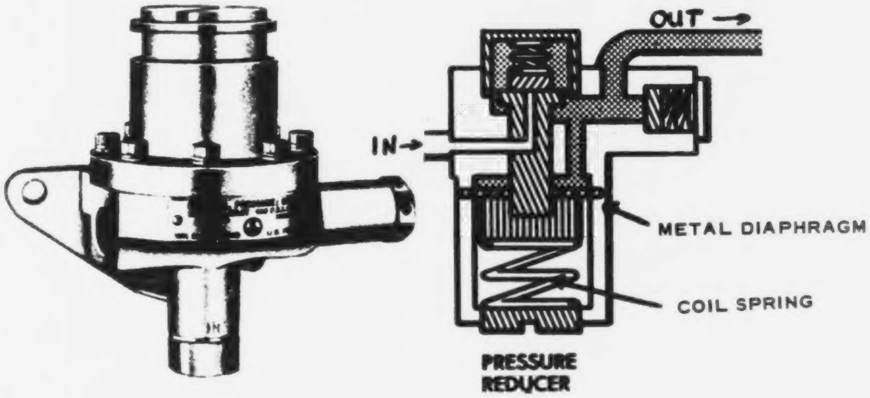
_____3. The filler valve separates the filler connection and cylinders.

_____4. The check valves are used to prevent reverse flow.

Answers to Frame 15: ✓ 1. _____2. ✓ 3. ✓ 4.

Frame 16

A separate pressure reducing valve is used in high pressure oxygen systems to drop the cylinder pressure from 1,800 psi to 300 to 400 psi before it goes in the regulator. This valve has a relief section that vents the pressure overboard if the reducing section fails to work. This is a safety feature to stop the regulators from rupturing if the valve fails to work. The major parts are a metal diaphragm and a coil spring assembly.



Check the following statement/s that are true.

_____1. The pressure reducer drops the cylinder pressure from 1,800 psi to between 300 to 400 psi.

_____2. If the pressure reducing valve malfunctions and the relief valve vents the pressure overboard, the regulator will rupture.

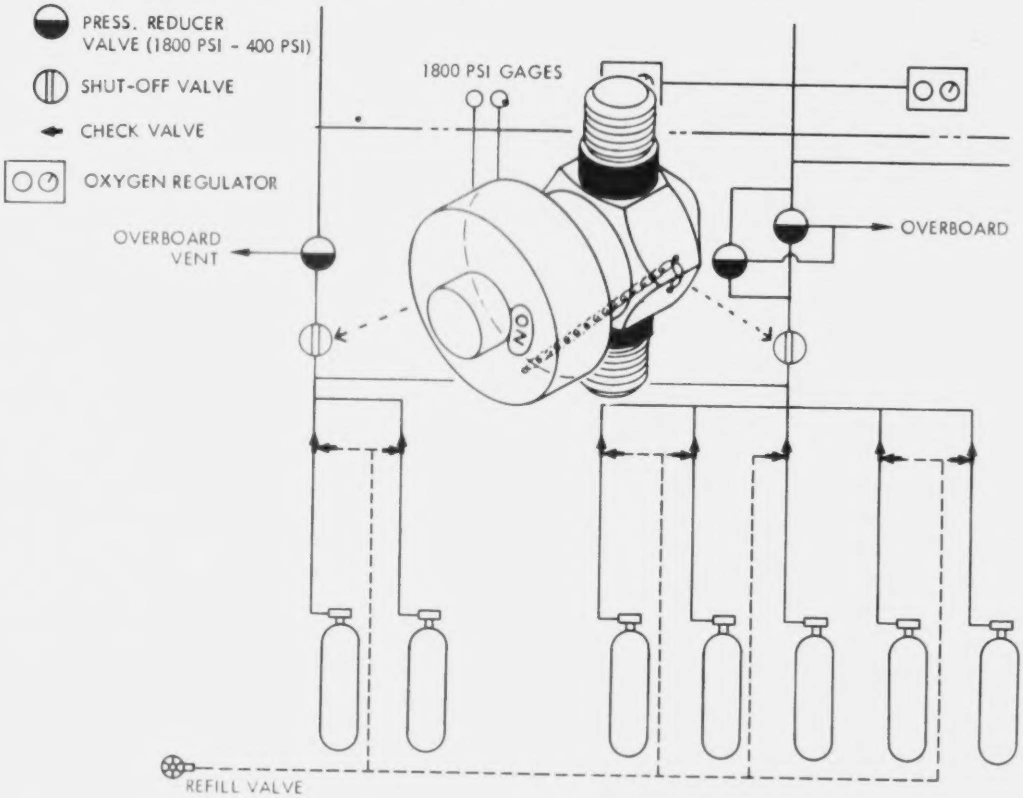
_____3. The major parts of a pressure reducer valve are a metal diaphragm and a coil spring assembly.

_____4. The pressure reducer valve contains a relief section.

Answers to Frame 16: ___✓___1. ______2. ___✓___3. ___✓___4.

Frame 17

The system shutoff valve used in the high pressure oxygen system is placed between the cylinders and the pressure reducing valve. This is a manual hand wheel operated valve that is normally safety-wired to the open position. In case of an emergency this valve can be closed to isolate the distribution system from the cylinders. It can also be used when maintenance is done on the system. The valve should always be left in the open position and safety-wired. The position that the shutoff valve is in (on or off) can be seen through a window in the top of the control knob.


PRESS. REDUCER VALVE (1800 PSI - 400 PSI)
SHUT-OFF VALVE
CHECK VALVE
OXYGEN REGULATOR
1800 PSI GAGES
OVERBOARD VENT
OVERBOARD
ON
REFILL VALVE

Check the following statement/s that are true.

______1. The system shutoff valve is hand wheel operated.

______2. The shutoff valve is always closed.

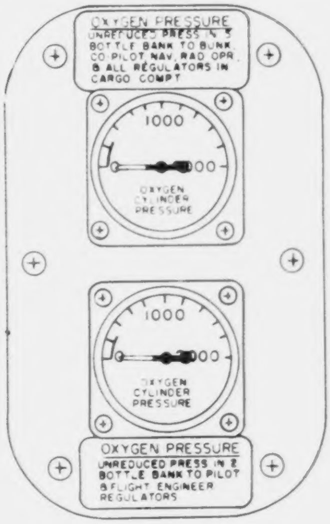
______3. The shutoff valve is located between the cylinders and pressure reducing valve.

______4. The valve is normally in the open position and safety-wired.

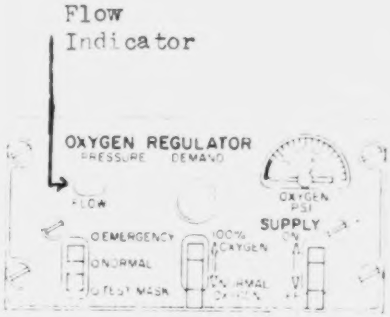
Answers to Frame 17: ✓ 1. ____ 2. ✓ 3. ✓ 4.

Frame 18

A pressure gage is used to show cylinder pressure. Some aircraft have two systems and both pressure gages are shown. Keep in mind that this is cylinder pressure and not reduced pressure. The gage is tapped into the syteem before the pressure reducing valve. The gage is bourdon tube operated and reads from 0 to 2,000 psi, with increments of 200 psi marked off on the dial. The regulator that is used on the C-130 aircraft has a flow indicator built in to let the user know that oxygen is flowing through the regulator. When the user takes a breath of oxygen, a "flag" attached to a diaphragm shows through a glass window on the face of the regulator.


OXYGEN PRESSURE
UNREDUCED PRESS IN 5 BOTTLE BANK TO BUNK, CO-PILOT NAV, RAD OPR, & ALL REGULATORS IN CARGO COMPT
1000
000
OXYGEN CYLINDER PRESSURE
1000
000
OXYGEN CYLINDER PRESSURE
OXYGEN PRESSURE
UNREDUCED PRESS IN 2 BOTTLE BANK TO PILOT & FLIGHT ENGINEER REGULATORS

TANK PRESSURE GAGES


Flow Indicator
OXYGEN REGULATOR
PRESSURE DEMAND
FLOW
OXYGEN PSI
SUPPLY
ON
EMERGENCY
NORMAL
TEST MASK
100% OXYGEN
NORMAL OXYGEN

OXYGEN REGULATOR

Check the following statement/s that are true.

_____ 1. The pressure gage indicates cylinder pressure.

_____ 2. The diagram above shows two separate pressure gages.

_____ 3. The flow indicator on the C-130 is part of the regulator.

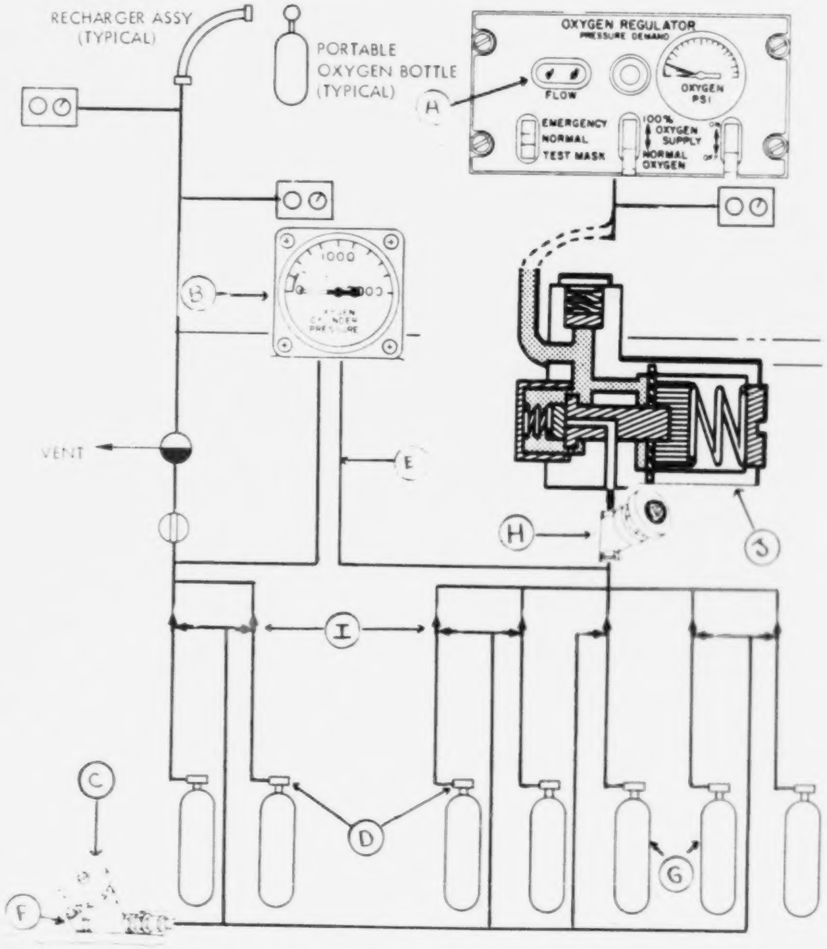
_____ 4. The flow indicator on the C-130 is the A-3.

_____ 5. The pressure gage is bourdon tube-operated.

Answers to Frame 18: ___✓___ 1. ___✓___ 2. ___✓___ 3. ______ 4. ___✓___ 5.

Frame 19

Match the letter shown at each component with the correct name of that component from the list below.


RECHARGER ASSY (TYPICAL)
PORTABLE OXYGEN BOTTLE (TYPICAL)
OXYGEN REGULATOR
PRESSURE DEMAND
FLOW
OXYGEN PSI
EMERGENCY
NORMAL
TEST MASK
100% OXYGEN
SUPPLY
NORMAL OXYGEN
ON
OFF
1000
OXYGEN CYLINDER PRESSURE
VENT
A
B
C
D
E
F
G
H
I
J

______1. Oxygen Filler Valve

______2. System Shutoff Valve

______3. Oxygen Flow Indicator

______4. Pressure Reducing Valve

______5. Stainless Steel Tubing

______6. Oxygen Filler Connection

______7. Automatic Valve Assembly

______8. Cylinder Pressure Gage

______9. Check Valves

_____10. High Pressure Cylinders

Answers to Frame 19: C 1. H 2. A 3. J 4. E 5.
F 6. D 7. B 8. I 9. G 10.

PROGRAMMED TEXT
3ABR42331-PT-401B

Technical Training

Aircraft Environmental Systems Mechanic

DEMAND OXYGEN EQUIPMENT

17 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 9.8

OBJECTIVE

Relate four of five demand oxygen system components to their operation.

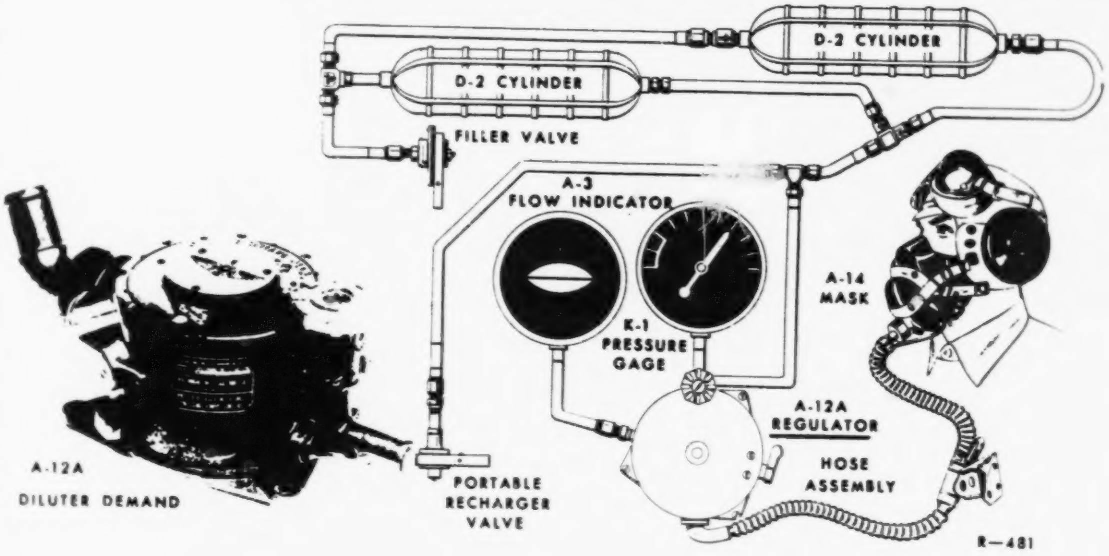
INSTRUCTIONS

This programmed text presents material in small steps called "frames." After each frame you will find a number of statements and you are asked to select the statement/s that are true. Read the material in each frame before making a selection. The answers to each frame can be found at the top of the next page. If you select the correct answers, continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before continuing.

Supersedes 3ABR42331-PT-401B, 3 August 1978.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; DAV - 1

In the illustration below, D-2 low pressure gaseous oxygen cylinders are being used in the supply section of this system. Do we call this a gaseous oxygen system? No. Oxygen systems are usually referred to by the type of regulator installed in the distribution section of the system. The system shown has the A-12A diluter DEMAND regulator installed and we call this a DEMAND oxygen system. If the system below has a continuous flow regulator installed, it would be referred to as a continuous flow system, etc. Other components of the demand system are the A-14 demand mask, A-3 flow indicator, K-1 pressure gage, and the mask-to-regulator hose.

DEMAND OXYGEN SYSTEM


D-2 CYLINDER
D-2 CYLINDER
FILLER VALVE
A-3 FLOW INDICATOR
K-1 PRESSURE GAGE
A-14 MASK
A-12A REGULATOR
HOSE ASSEMBLY
A-12A DILUTER DEMAND
PORTABLE RECHARGER VALVE
R-481

Check the following statements that are true.

____ 1. Usually an oxygen system is referred to by the type of regulator installed.

____ 2. The A-12A regulator is the diluter demand type.

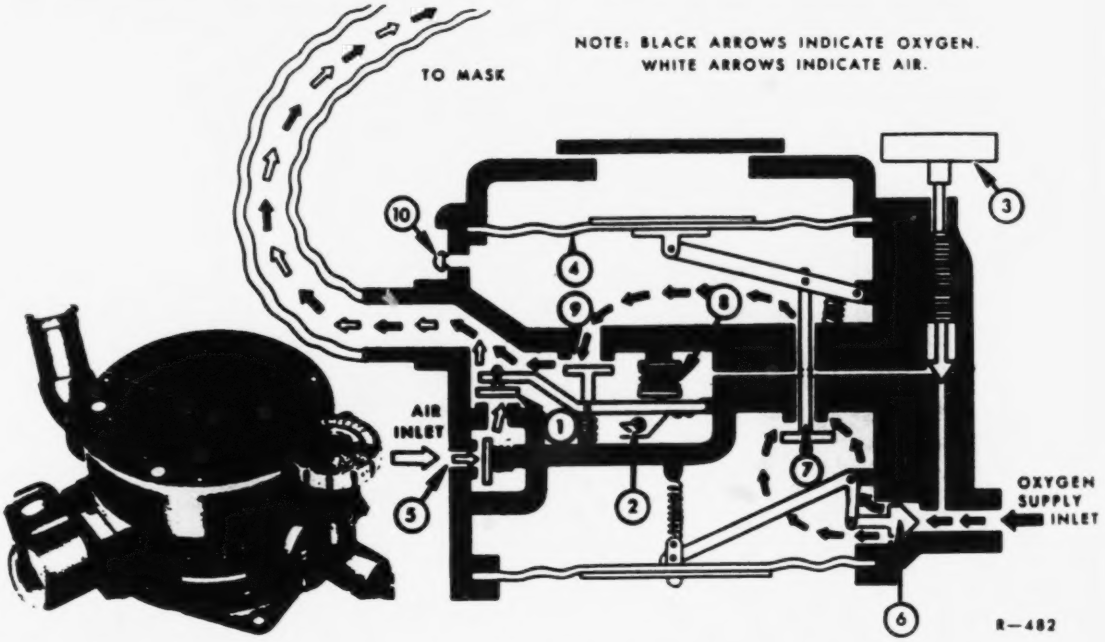
____ 3. The A-12A regulator is used only with liquid oxygen systems.

____ 4. The A-14 demand mask is used with the A-12A regulator.

Answers to Frame 1: 1.__✓__ 2.__✓__ 3.____ 4.__✓__

Frame 2

The A-12A diluter demand regulator gets its name from the fact that it delivers oxygen to your lungs in response to the suction of your own breath, that is, on demand. To prolong the duration of the supply, the oxygen is automatically diluted (mixed) in the regulator with suitable amounts of air up to a certain altitude. The A-12A is one of the oldest oxygen regulators in use and we will discuss it first because the newer regulators are patterned after the A-12A; this will become apparent as we continue. For a better understanding of the A-12A, mentally match the list of components with the numbers in the arrowed circles.


NOTE: BLACK ARROWS INDICATE OXYGEN.
WHITE ARROWS INDICATE AIR.
TO MASK
AIR INLET
OXYGEN SUPPLY INLET
1
2
3
4
5
6
7
8
9
10
R—482

1.	Air Metering Port.	6.	Pressure Reducing Valve.
2.	Diluter Control Cam.	7.	Demand Valve.
3.	Emergency Valve.	8.	Aneroid.
4.	Demand Diaphragm.	9.	Oxygen Metering Port.
5.	Check Valve.	10.	2nd Stage Relief Valve.

Type A-12A Diluter Demand Oxygen Regulator (Aro).

Check the following statements that are true.

____ 1. The A-12A delivers oxygen on demand.

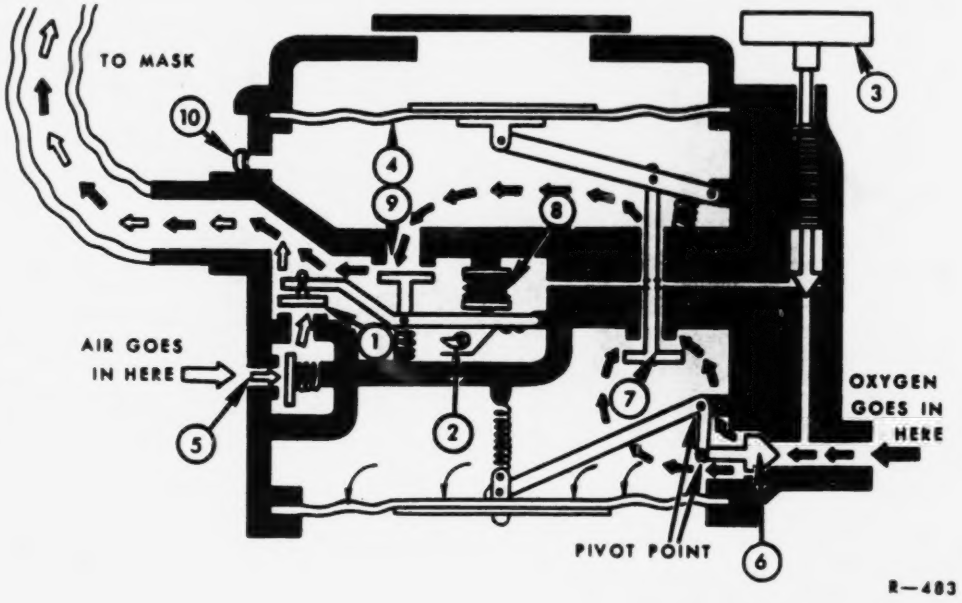
____ 2. The A-12A delivers 100% oxygen at all times.

____ 3. Air is mixed with the oxygen in the regulator up to a certain altitude.

Answers to Frame 2: 1. ✓ 2. ___ 3. ✓

Frame 3

As we have stated, the A-12A is a diluter demand regulator. This simply means that air and oxygen are mixed (diluted) and supplied to the user when he/she inhales (demands) oxygen. When the user inhales, he/she closes a valve in the mask and opens a valve in the regulator. When he/she exhales, this process is reversed. Starting where the oxygen enters the regulator from the supply section you find the pressure reducing mechanism. The pressure reducing valve (6) is attached through levers to a rubber diaphragm. (See schematic.) As the pressure of the oxygen increases in this first stage chamber, it forces the diaphragm down and the attached lever closes the pressure reducing valve (6). 40 to 60 psi on the diaphragm closes the valve and it remains closed until the pressure drops from the oxygen being used. Note the spring attached to the center of the diaphragm will also help pull it up which will open the valve.



1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.
10. 2nd Stage Relief Valve.

Type A-12A Diluter Demand Oxygen Regulator (Aro).

Check the following statements that are true.

____ 1. 40 to 60 psi closes the pressure reducing valve.

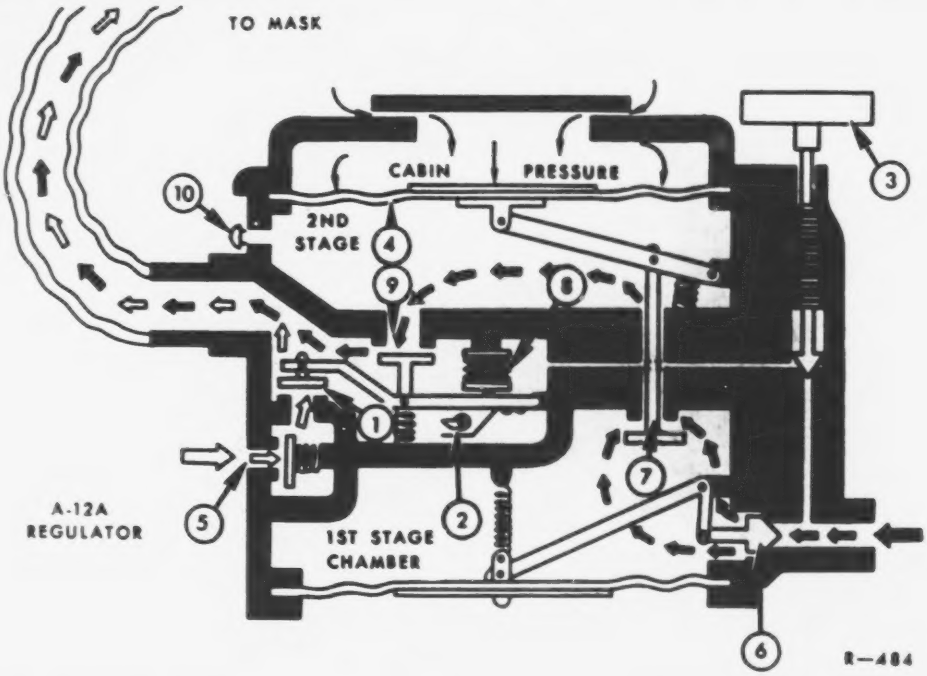
____ 2. The user does not have to inhale to get oxygen from the A-12A.

____ 3. First stage reducing is 40 to 60 psi.

Answers to Frame 3: 1. ✓ 2. ___ 3. ✓

Frame 4

We now have 40 to 60 psi in the first stage chamber. The only way for the oxygen to get out of here is up around the demand valve (7). (See schematic.) The demand valve (7) is controlled through levers attached to the demand diaphragm (4). The demand diaphragm is controlled in turn by the breathing of the user. Cabin pressure acts on the upper side of the demand diaphragm (4). As the user inhales oxygen is drawn from the bottom side of the diaphragm. This allows cabin pressure to force the diaphragm down. The connecting levers then open the demand valve (7) and more oxygen is allowed in the upper or 2nd stage chamber. Once the 2nd stage chamber pressure equals the cabin pressure, oxygen pressure raises the diaphragm enough to close the demand valve. The above sequence is the way 1st stage pressure is reduced for pilot use.



1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.
10. 2nd Stage Relief Valve.

Check the following statements that are true.

___ 1. The demand valve is controlled by the demand diaphragm.

___ 2. The demand diaphragm is controlled by the user.

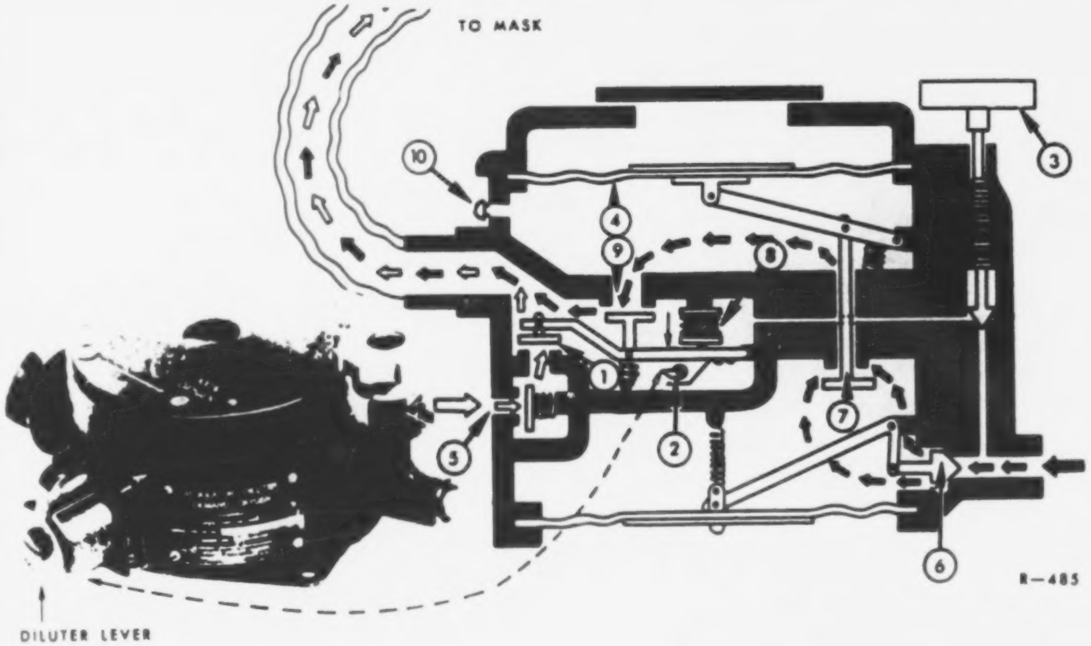
___ 3. Oxygen enters the second stage chamber through the demand valve.

___ 4. The demand diaphragm directly controls the pressure reducing valve.

Answers to Frame 4: 1. ✓ 2. ✓ 3. ✓ 4. ___

Frame 5

When the user inhales (demands oxygen) the oxygen leaves the 2nd stage chamber thorugh the oxygen metering port (9), and travels to the user in the mask-to-regulator hose. At the same time, cabin air is allowed to mix with (dilute) the oxygen. The air enters through the check valve (5); then a specified amount is metered through the air metering port (1). Note that the oxygen metering port and air metering port are attached to a common lever which moves up or down. The diluter control cam (2) has two positions which are selected by the diluter lever, (see illustration). With the diluter lever positioned to "normal oxygen," the aneroid (8) will control the movement of the common lever. And as cabin altitude increases, the aneroid will expand an gradually close off the air metering port. At 32,000 feet the air metering port will be completely closed and the user will get 100% oxygen automatically



1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.
10. 2nd Stage Relief Valve.

Check the following statements that are true.

___ 1. Up to 32,000 feet, air and oxygen are mixed.

___ 2. The check valve (5) shuts off the air at 32,000 feet.

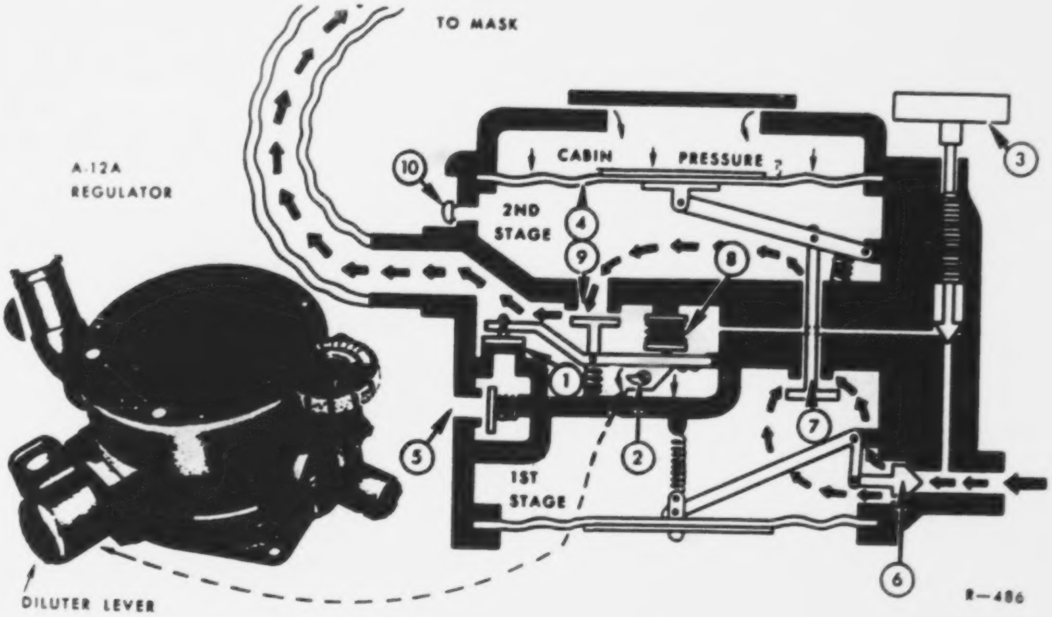
___ 3. With the diluter lever in normal oxygen, the aneroid controls the air.

___ 4. Above 32,000 feet, the user automatically gets 100% in the normal oxygen position.

Answers to Frame 5: 1. ✓ 2. ___ 3.

Frame 6

As we have stated, with the diluter lever in "NORMAL OXYGEN," the aneroid (8) will control the amount of air entering the regulator and at 32,000 feet it closes air metering port. When the diluter lever is manually placed in the "100% OXYGEN" position, the diluter control cam (2) swings down as indicated in the schematic and engages a strip of metal attached to the common lever and forces the lever down. This action overrides the aneroid and closes off the air metering port (1). This action supplies the user with 100% oxygen anytime he/she so desires.



1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.
10. 2nd Stage Relief Valve.

Check the following statements that are true.

___ 1. The diluter lever allows the user to select 100% oxygen at anytime.

___ 2. The diluter lever moves the diluter control cam.

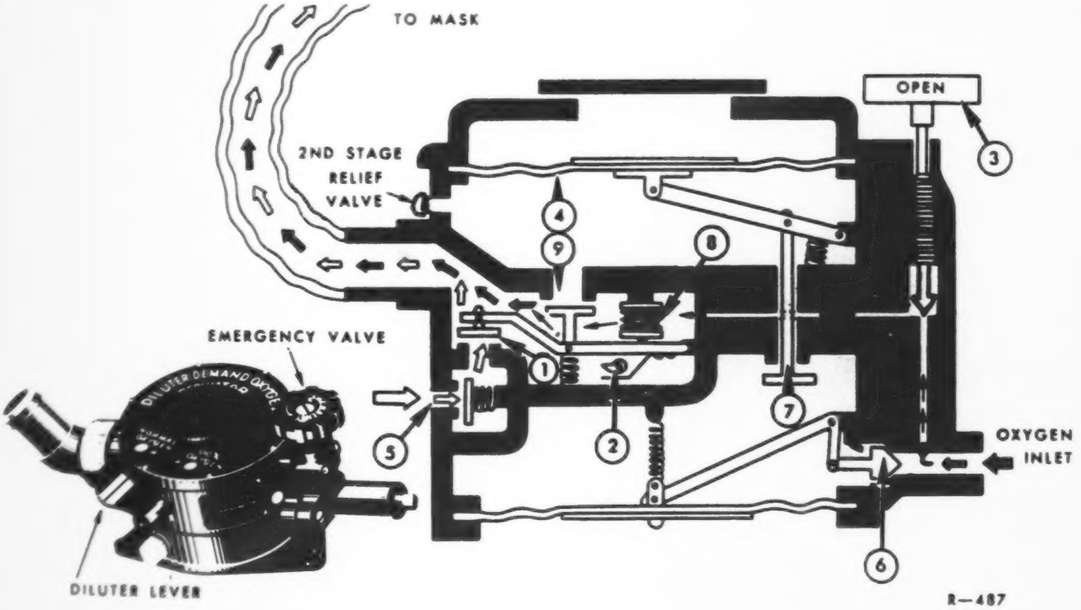
___ 3. The diluter lever overrides the aneroid when placed in 100% oxygen.

___ 4. The diluter lever controls the first stage reducing.

Answers to Frame 6: 1. ✓ 2. ✓ 3. ✓ 4.

Frame 7

The only section of the A-12A we have not covered is the EMERGENCY VALVE (3). This is a hand-wheel operated valve that opens an orifice as shown in the schematic. When the emergency valve (3) is turned out, oxygen will flow through this machined orifice in a continuous flow to the user. Should pressure build up in the regulator, a 2nd stage relief valve will open at 30 to 41 inches of water pressure to relieve it. The emergency valve is provided in case the regulator malfunctions or the user is unable to breathe normally. Remember, the normal function of this regulator requires that the user demand (inhale).



1. Air Metering Port.
2. Diluter Control Cam.
3. Emergency Valve.
4. Demand Diaphragm.
5. Check Valve.
6. Pressure Reducing Valve.
7. Demand Valve.
8. Aneroid.
9. Oxygen Metering Port.

Check the following statements that are true.

___ 1. The emergency valve allows the user to get a continuous flow of oxygen.

___ 2. The 2nd stage relief valve opens at 30 to 41 inches of water pressure.

___ 3. The emergency valve will open automatically.

___ 4. The normal function of the A-12A requires the user to inhale.

Answers to Frame 7: 1. ✓ 2. ✓ 3. __ 4. ✓

Frame 8

SELF TEST QUIZ

In each question, circle the letter that identifies the correct answer. Check your answers on the top of the next page.

1. The second stage relief valve in the A-12A will open and relieve pressure at

   a. cabin pressure.
   b. 5 psi.
   c. 15 inches of mercury.
   d. 30 to 41 inches of water.

2. The A-12A oxygen regulator is a

   a. diluter demand regulator.
   b. pressure demand regulator.
   c. continuous flow regulator.
   d. diluter pressure demand regulator.

3. A complete oxygen system with the A-12A regulator installed would be referred to as a

   a. high pressure oxygen system.
   b. diluter oxygen system.
   c. demand oxygen system.
   d. low pressure oxygen system.

4. The pressure reducing mechanism in the A-12A oxygen regulator reduces cylinder pressure to

   a. 40 to 60 inches of water.
   b. 40 to 60 inches of mercury.
   c. 40 to 60 psi.
   d. cabin pressure.

5. If the user of the A-12A regulator became injured or for some other reaso could not breathe normally, he would

   a. put the diluter lever in "normal oxygen."
   b. use a walk-around bottle.
   c. open the emergency valve.
   d. place the diluter lever in "100% oxygen."

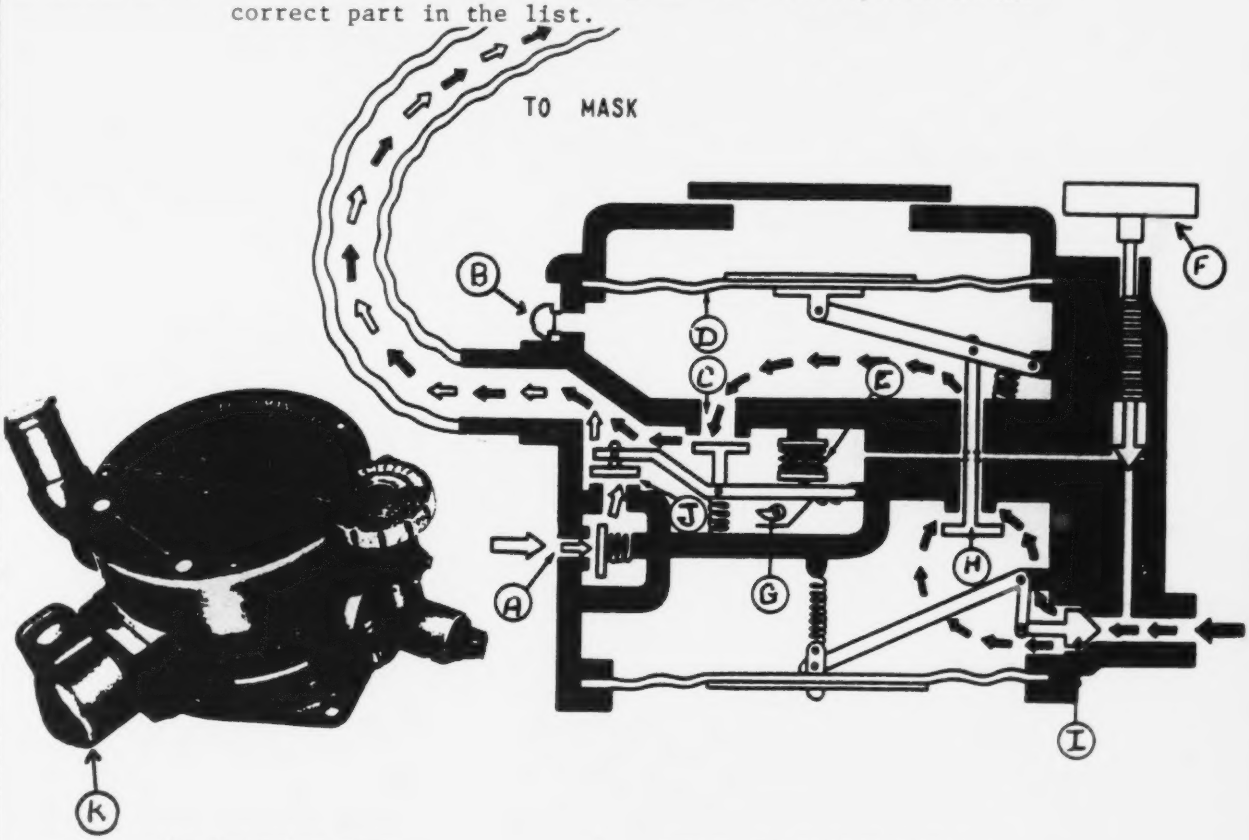
6. In the A-12A demand regulator, the demand diaphragm opens and closes the demand valve in direct response to

   a. atmospheric pressure.
   b. the setting of the diluter lever.
   c. the aircraft altitude.
   d. the breathing of the user.

Answers to Frame 8: 1. d 2. a 3. c 4. c 5. c 6. d

Frame 9

INSTRUCTIONS: Place the letter in the diagram that corresponds to the correct part in the list.



_____1. Air Metering Port

_____2. Diluter Control Cam

_____3. Emergency Valve

_____4. Demand Diaphragm

_____5. Check Valve

_____6. Pressure Reducing Valve

_____7. Demand Valve

_____8. Aneroid

_____9. Oxygen Metering Port

____10. Diluter Lever

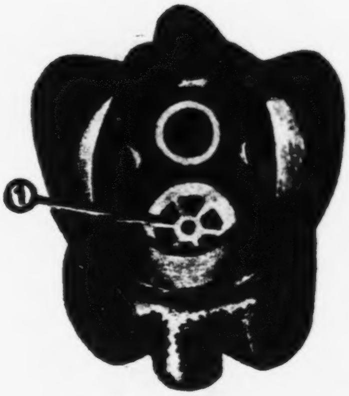
____11. Relief Valve

Type A-12A Diluter Demand Oxygen Regulator (Aro).

Answers to Frame 9:

1. J
2. G
3. F
4. D
5. A
6. I
7. H
8. E
9. C
10. K
11. B

The A-14 or A-14A demand mask is used with the A-12A demand oxygen regulator. The demand mask has a single outlet valve (1). This is a one-way check valve consisting of a circular flap of rubber which opens the outlet when the user exhales and closes it when he inhales. Proper regulator operation depends upon how well the mask fits and how well it is functioning. Oxygen masks are normally maintained by Personal Equipment Specialists and by the user. Knowing how they function will help you understand more clearly the oxygen regulators.



A-14A Demand Mask.

Check the following statements that are true.

___ 1. The A-14 mask has a single outlet valve.

___ 2. Regulator operation is affected by the mask.

___ 3. The demand mask is used with a demand regulator.

___ 4. Any mask can be used with any regulator.

Answers to Frame 10: 1. ✓ 2. ✓ 3. ✓ 4.

Frame 11

Another part of the demand oxygen system is the flow indicator and pressure gage. These two indicators are located close to the oxygen regulator and should be clearly visible to the user. The A-3 flow indicator is diaphragm operated and "blinks" at the user as he/she breathes. This lets the user know that oxygen is flowing through the regulator. The K-1 pressure gage is bourdon tube operated. As pressure inside the tube tends to straighten it, the pointer is moved through a system of levers. The pressure gage lets the user know how much oxygen is in the system that he/she is breathing from.

BLINKER
OXYGEN FLOW
INDICATOR

A-3 Flow Indicator.

OXYGEN
CYL.
PRESSURE

K-1 Pressure Gage.

Check the following statements that are true.

___ 1. The K-1 pressure gage is bourdon tube operated.

___ 2. The A-3 flow indicator operates from a bourdon tube.

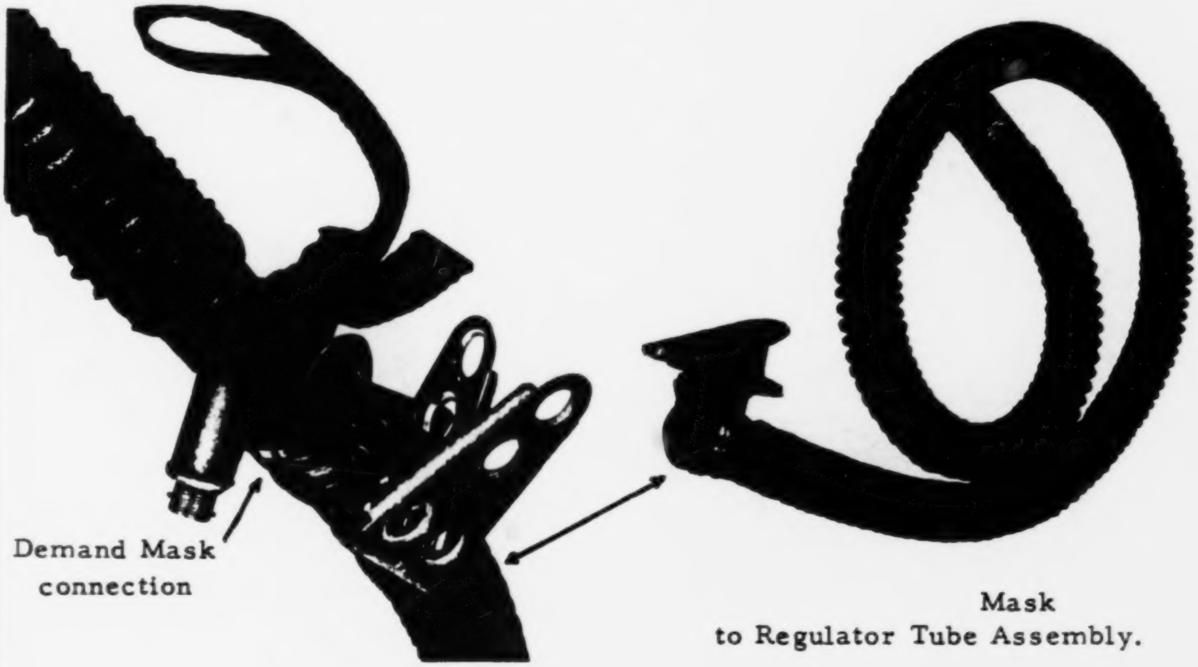
___ 3. The flow indicator "blinks" as the user breathes.

___ 4. The flow indicator and pressure gage are located near the regulator.

Answers to Frame 11. 1. ✓ 2. ___ 3. ✓ 4. ✓

Frame 12

Shown below is the flexible tubing or hose used to deliver the oxygen from the regulator to the mask. The plain end of the mask to regulator tube assembly (right below) is clamped to the outlet elbow of the demand regulator. The other end of the hose contains a clothing clip, dust cap, and female part of a quick disconnect. The male part of the quick disconnect is attached to hose connected to the demand mask (left below). A leakproof connection is made when both halves of the quick disconnect are joined.



Check the following statements that are true.

___ 1. One end of the mask to regulator tube has a clothing clip and a dust cap.

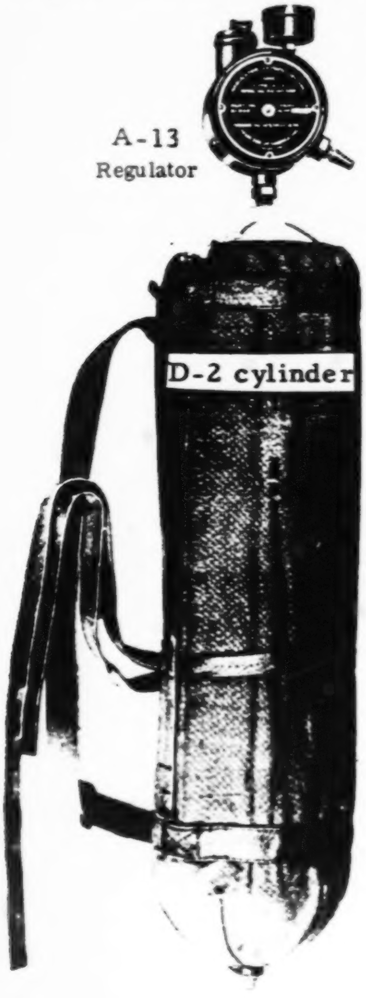
___ 2. The male part of the quick disconnect is attached to the mask hose.

___ 3. The quick disconnect will always leak.

Answers to Frame 12: 1. ✓ 2. ✓ 3.

Frame 13

Other than the station regulators like the A-12A, regulators are also used on small portable cylinders called "walk-around bottles." These bottles are carried on the larger type aircraft where crew members have to leave their station regulators to perform various duties while the aircraft is in flight. The older combination A-13 demand regulator and D-2 cylinder will supply oxygen for about 30 minutes before it has to be recharged from the aircraft main system. The A-13 demand regulator has no air inlet and supplies 100% oxygen on demand. The D-2 cylinder is serviced with 400 to 450 psi of oxygen. The carrying bag is used with this combination because of the weight of the D-2 cylinder.



Check the following statements that are true.

___ 1. Walk-around bottles would be needed on fighter aircraft.

___ 2. The A-13 is a straight demand regulator.

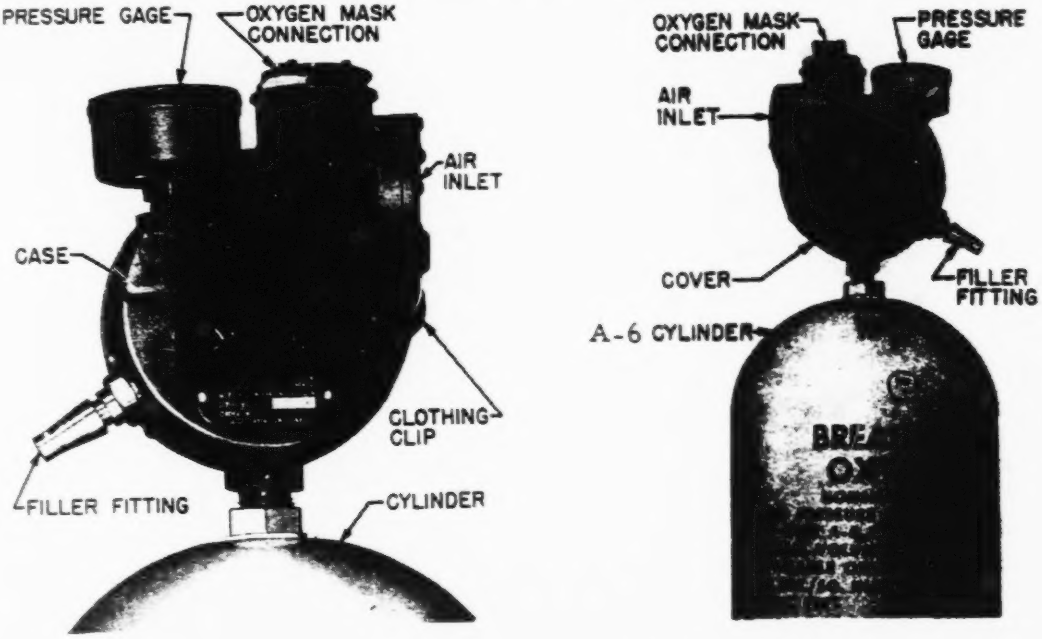
___ 3. The D-2 cylinder is filled from the aircraft system.

___ 4. The A-13 regulator supplies 100% oxygen on demand.

Answers to Frame 13: 1. ___ 2. ✓ 3. ✓ 4. ✓

Frame 14

The regulators used on walk-around bottles function the same as station regulators (A-12A) but are constructed somewhat different. The newer A-15 diluter demand regulator and A-6 cylinder are also part of the demand oxygen equipment. All portable regulators are constructed similar to the A-15 below with a 0 to 500 psi pressure gage, direct oxygen mask connection, filler fitting and clothing clip. The A-15 has an air inlet which tells us it's a diluter demand type. The A-6 cylinder is not as heavy as the D-2 cylinder previously discussed and a clothing clip is provided to attach it to the flying suit of the user. The A-6 is also serviced to 400-450 psi. The user has to constantly watch the pressure gage on walk-around bottles and recharge the cylinder before it is empty.


PRESSURE GAGE
OXYGEN MASK CONNECTION
AIR INLET
CASE
CLOTHING CLIP
FILLER FITTING
CYLINDER
OXYGEN MASK CONNECTION
PRESSURE GAGE
AIR INLET
COVER
FILLER FITTING
A-6 CYLINDER

A-15 Oxygen Regulator.

Check the following statements that are true.

___ 1. The A-15 is a portable, diluter demand regulator.

___ 2. On walk-around bottles, the cylinder is serviced through the regulators.

___ 3. Portable regulators are constructed the same as station regulators.

___ 4. The above unit is attached to the clothing of the user.

Answers to Frame 14 1. ✓ 2. ✓ 3. ___ 4. ✓

Frame 15

This concludes our discussion on demand oxygen equipment. The equipment covered in this text will be available in the classroom or oxygen lab for you to handle and inspect. Remember, oxygen equipment is depended upon by the user as his main life support at high altitudes. Failure of this equipment for a 15 second period may be fatal to the user. Also, while you are working with and handling oxygen and equipment, don't forget the safety precautions that apply to oxygen.

SELF TEST QUIZ

Circle the correct answer and check your answer on the next page.

1. The A-15 portable regulator differs from the A-13 portable regulator in that the

   a. A-15 has a demand function only.
   b. A-15 is diluter demand.
   c. A-13 has a filler fitting.
   d. A-13 has a pressure gage.

2 The type of oxygen mask used with the A-12A regulator in a demand oxygen system is the

   a. A13 pressure mask.
   b. A14 demand mask.
   c. K-1 diluter mask.
   d. A-3 mask.

3. The A-6 portable cylinder is used in combination with the

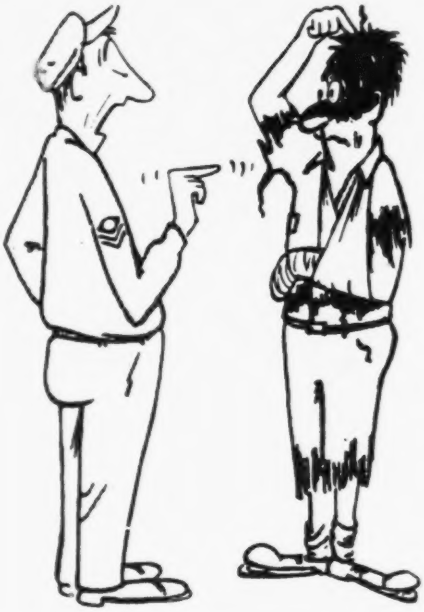
   a. A-15 diluter demand regulator.
   b. A-12A pressure regulator.
   c. A-13A diluter regulator.
   d. A-14 fixed regulator.

4. The A-13 and A-15 oxygen regulators are

   a. both diluter demand.
   b. station regulators like the A-12A.
   c. used on walk-around bottles.
   d. constructed the same as the A-12A.

Answers to Frame 15: 1. b 2. b 3. a 4. c

Remember Your Oxygen Safety



Keep all petroleum products (oil, grease, fuel, etc) away from oxygen equipment.

Make sure that body, clothing, and protective equipment are clean and free of petroleum products (hair oil is a petroleum product) before performing maintenance on oxygen system.

END OF TEXT

PROGRAMMED TEXT
3ABR42331-PT-401C

Technical Training

Aircraft Environmental Systems Mechanic

PRESSURE DEMAND OXYGEN EQUIPMENT

2 March 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: 9.3

OBJECTIVE

Relate four of five pressure demand oxygen system components to their operation.

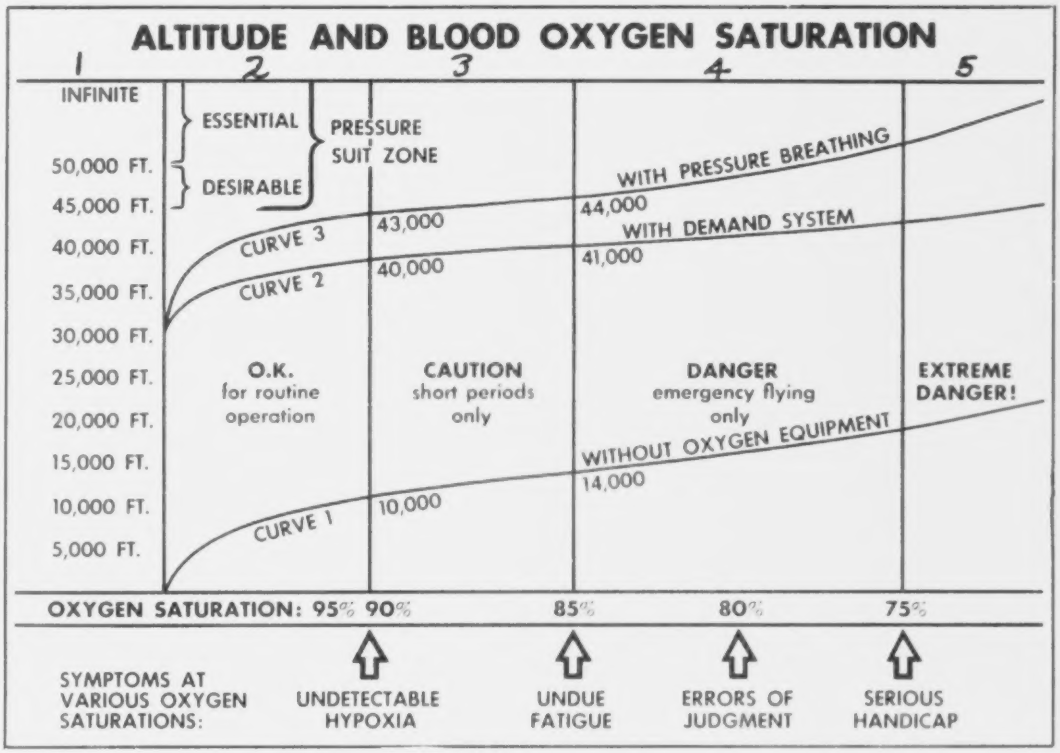
INSTRUCTIONS

This programmed text will review some of the parts taught in previous lessons on gaseous oxygen systems and cover in depth the operation of the regulators and mask that make the system a pressure demand system. In addition, the reason the pressure demand system is needed is explained.

The information in this text is presented in small steps called frames. After each frame you are asked to respond in some manner. Read the material carefully, then make your response as directed. The answers for the responses can be found on top of the next page. If you answered correctly, continue on to the next frame. If you are wrong or in doubt, read the technical material again and correct yourself before continuing.

Supersedes ST 3ABR42331-PT-401C, 15 March 1978.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; TTVSA - 1

The diluter demand regulator sends oxygen or oxygen mixed with air to the user on demand or when he breathes. This is all just fine until we reach a height of about 40,000 feet. From 40,000 feet up, the human body needs oxygen under pressure to work the way it should. At sea level pressure, carbon dioxide and water are stable in the blood stream and oxygen saturation of the blood is 100%. At low atmospheric pressure (high altitude), carbon dioxide and water vaporize in the lungs and pressure builds up that keeps oxygen from entering the lungs. By adding pressure to the oxygen (pressure breathing), we get rid of this pressure in the lungs and force the carbon dioxide out and force oxygen in. Look at the chart below for a better idea of the equipment required.



Using the chart above to determine the approximate altitude for each of the questions written below. Place your answer in the blank provided.

_____1. What is the limit of a demand oxygen regulator?

_____2. What is the safe limit a person can reach without oxygen equipment?

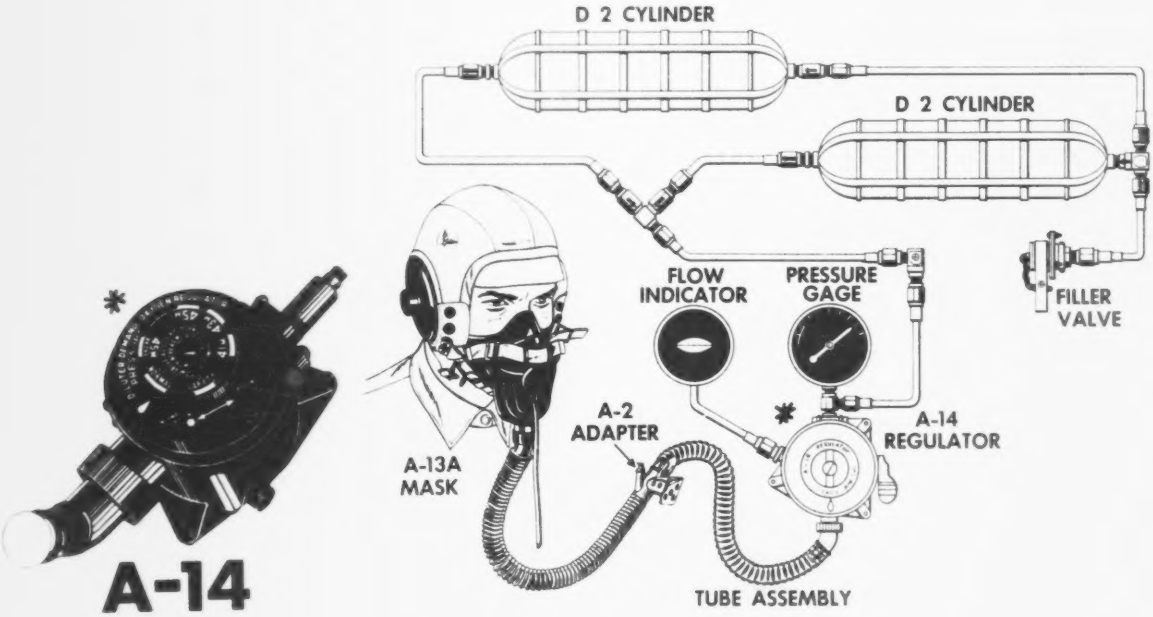
_____3. At what altitude is a pressure suit desirable?

_____4. How high can a pilot safely fly with a pressure breathing system?

Answers to Frame 1: 1. 40,000 2. 10,000 3. 45,000 4. 44,000

Frame 2

With pressure breathing, as shown in the chart in the past frame, we are safe up to a height of about 50,000 feet. Above this height, the carbon dioxide and water vapor pressure will rise to a point where any more of an increase in oxygen pressure would damage the lungs. Also, above 50,000 feet, a pressure suit is needed in case cabin pressure is lost. Without any pressure, blood will boil at 60,000 feet, so you can see the need of this equipment. Now that you know why we need pressure breathing, let us talk about some of the regulators that make up a pressure-demand system. Shown below is a complete oxygen system with the A-14 pressure demand regulator used. Note that the change found between this system and the straight demand system is in the regulator and mask used. The A-14 is a pressure demand regulator and the A-13A is a pressure demand mask.


D 2 CYLINDER
D 2 CYLINDER
FILLER VALVE
FLOW INDICATOR
PRESSURE GAGE
*
A-14 REGULATOR
A-2 ADAPTER
A-13A MASK
TUBE ASSEMBLY
*
A-14

Check the following statements that are true.

_____1. The A-14 is a pressure demand oxygen regulator.

_____2. The A-12A regulator can be used above 50,000 feet.

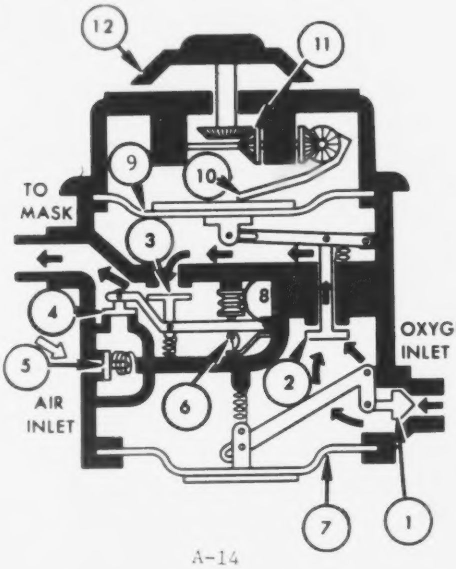
_____3. Above 50,000 feet, a pressure suit is essential.

Answers to Frame 2: ✓ 1. ___ 2. ✓ 3.

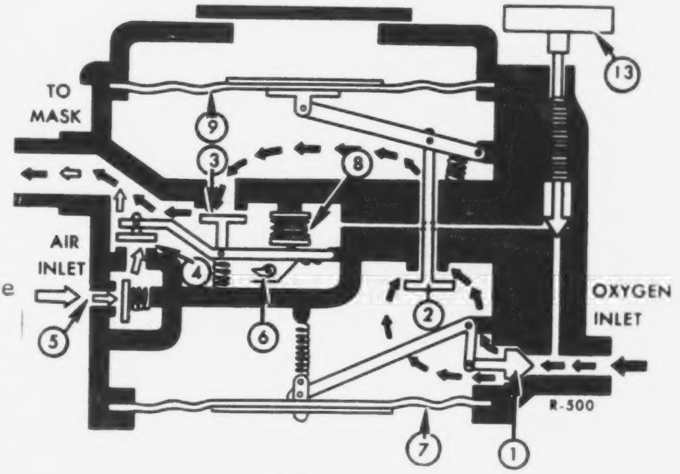
Frame 3

Take a look at the difference between the A-14 (top) and the A-12A (lower) regulators. If you place your finger over the top section of the A-14 you will see that we have an A-12A regulator again, except for the EMERGENCY VALVE (13) on the A-12A. One of the settings on the A-14 dial will serve as an emergency setting. Keep in mind when we talk about the A-14 regulator that except for the pressure breathing section located on top, this regulator will work the same way as the A-12A. Match all the parts listed below with the A-14 regulator.

9r


12
11
TO MASK
9
10
3
8
4
OXYGEN INLET
5
2
6
AIR INLET
7
1

A-14


13
TO MASK
9
3
8
AIR INLET
4
2
OXYGEN INLET
5
6
R-500
7
1

A-12A

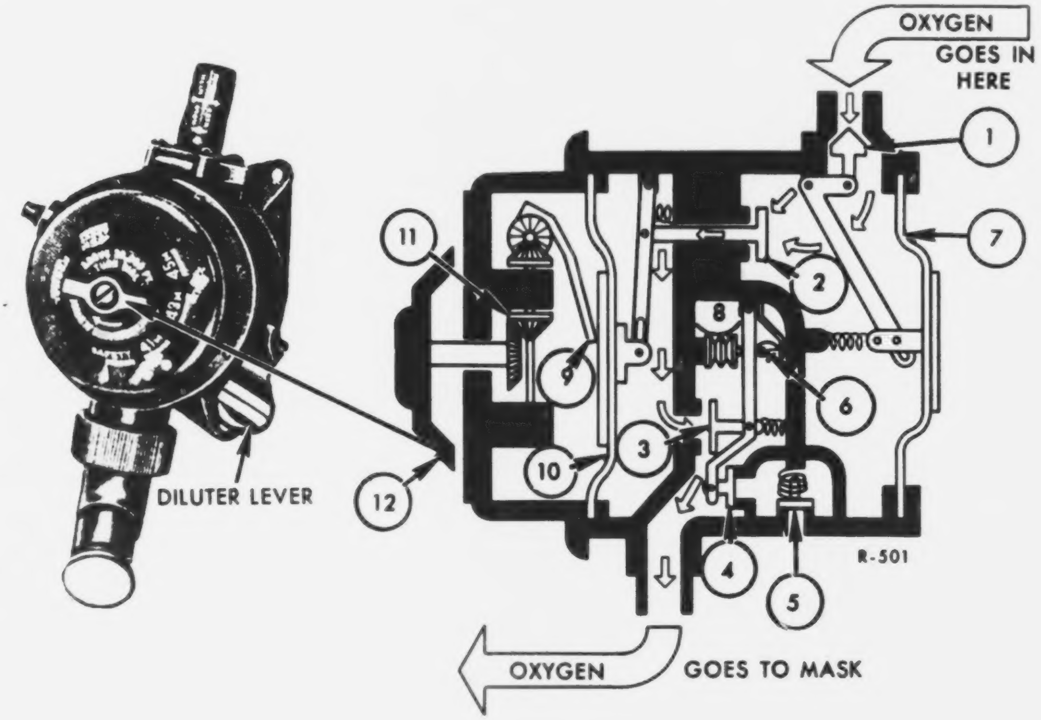
1. Pressure Reducing Valve
2. Demand Valve
3. Oxygen Metering Valve
4. Air Valve
5. Check Valve
6. Diluter Valve
7. Diaphragm
8. Aneroid
9. Demand Diaphragm
*10. Pressure Breathing Lever
*11. Pressure Breathing Gear Train
*12. Pressure Breathing Control Knob
**13. Emergency Valve

*A-14 **A-12A

No Response Required

Frame 4

The A-14 regulator is a pressure-breathing, diluter-demand regulator. The diluter lever works the diluter control cam (6). In the 100% oxygen position, the diluter control cam will press down on the metal strip hooked to the common lever and close the air valve (4). The regulator is now delivering 100% oxygen. With the diluter lever in the NORMAL OXYGEN position, the air is controlled by the aneroid (8) up to 32,000 feet at which time it, the air valve (4), will be closed off (same as the A-12A). Match the part name with the number in the arrowed circles for a better understanding.



A-14 PRESSURE-BREATHING DILUTER-DEMAND REGULATOR

1. Pressure Reducing VAlve
2. Demand Valve
3. Oxygen Metering Valve
4. Air Valve
5. Check Valve
6. Diluter Control Cam
7. Diaphragm
8. Aneroid
9. Pressure Breathing Lever
10. Demand Diaphragm
11. Pressure Breathing Gear Train
12. Pressure Breathing Control Knob

Place the number of the part in the blank space next to the statement that best describes its operation/use.

_____a. Worked by the diluter lever.

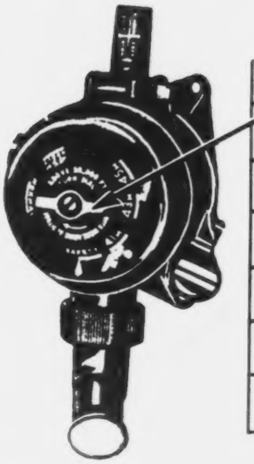
_____b. The diluter control cam presses on a metal strip attached to the common lever and closes this valve.

_____c. Controls the air up to 32,000 feet with the diluter lever

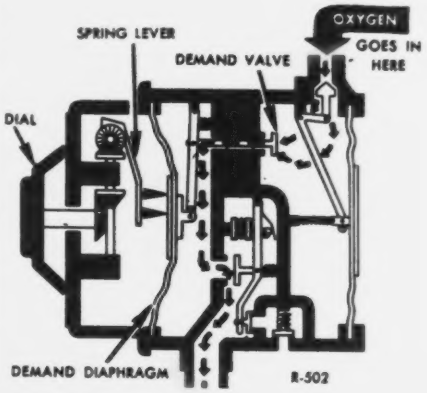
Answers to Frame 4: 6 a. 4 b. 8 c.

Frame 5

The pressure breathing control knob or selector dial on the A-14 has six (6) positions that the user can choose from as he goes from sea level to above 45,000 feet. As shown in the regulator sketch below, the dial is hooked to a gear train which in turn will crank down the spring lever and force the demand diaphragm to open the demand valve. The first column in the chart shown lists the six different settings. In NORMAL, no pressure is placed on the demand diaphragm and the A-14 will work the same as the A-12A. The second column lists the altitude at which each setting should be used, and the third column lists the pressure that is sent to the mask. (Note: On the dial setting, "M" = thousands). In case of emergency, the setting "ABOVE 45M" is used.



DIAL SETTING		DELIVERED PRESSURE
NORMAL	0 30,000	NO PRESSURE SAME AS A-12A
SAFETY	30,000 39,000	0.04PSI
41M	39,000 41,000	0.15PSI
43M	41,000 43,000	0.21PSI
45M	43,000 45,000	0.29PSI
ABOVE 45M EMERGENCY		0.43PSI



PRESSURE SETTINGS AND PRESSURE DELIVERED.

Refer to the chart above to complete each of the following statements.

1. The emergency setting on the A-14 regulator delivers __________ PSI to the mask.

2. The safety setting will be used at altitudes between __________ and __________.

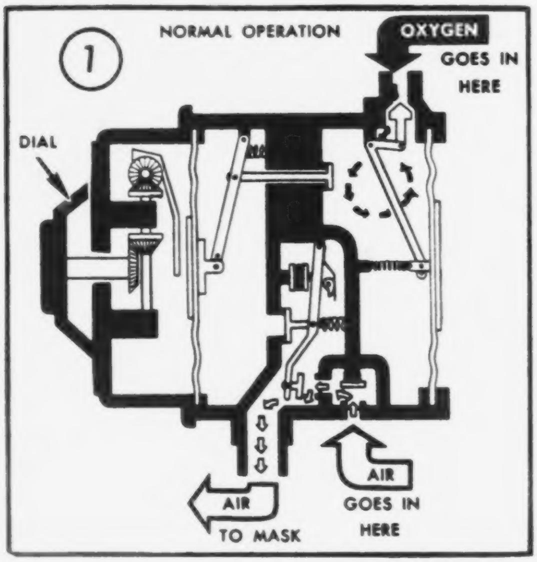
3. At the 43M setting __________ PSI is delivered to the mask.

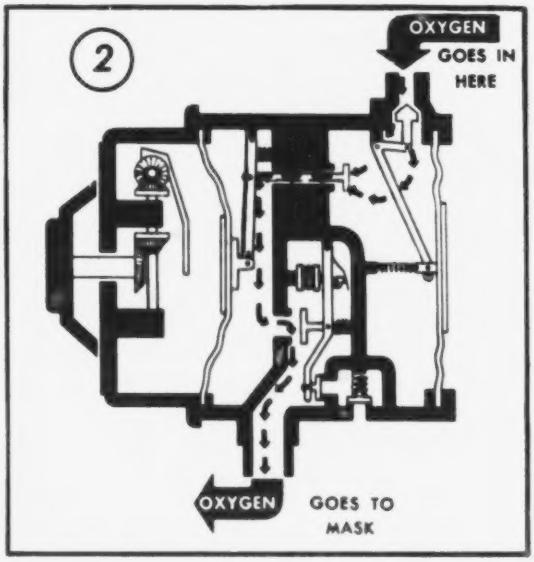
4. At 39,000 feet the dial setting should be changed from SAFETY to __________.

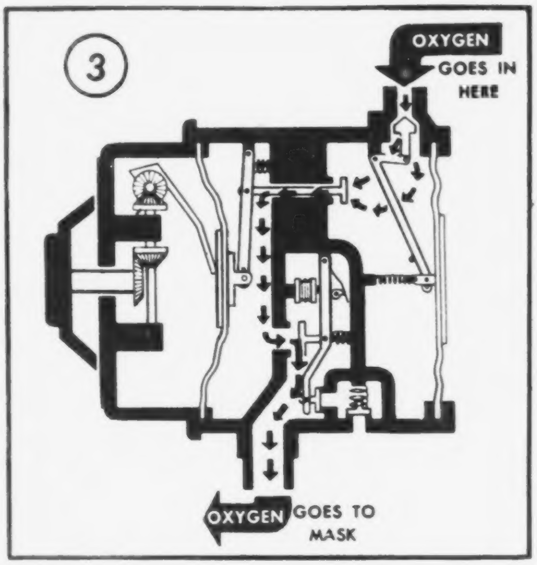
Answers to Frame 5: 1. 0.43 2, 30,000 ft, 39,000 ft 3. 0.21
4. 41M

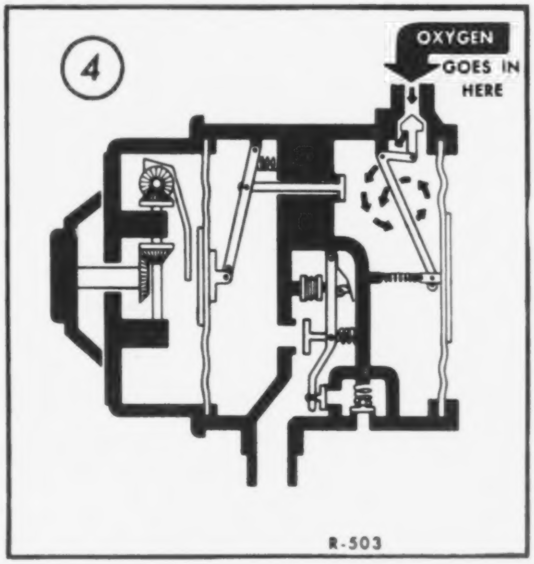
Frame 6

The first schematic below shows operation at sea level. The dial would be set at "NORMAL." Anytime that the regulator is not being used it must be set on "NORMAL" or else spring tension on the demand diaphragm will drain the system. Study all of the schematics and read the information that tells just what is taking place.


①
NORMAL OPERATION
OXYGEN
GOES IN
HERE
DIAL
AIR
TO MASK
AIR
GOES IN
HERE

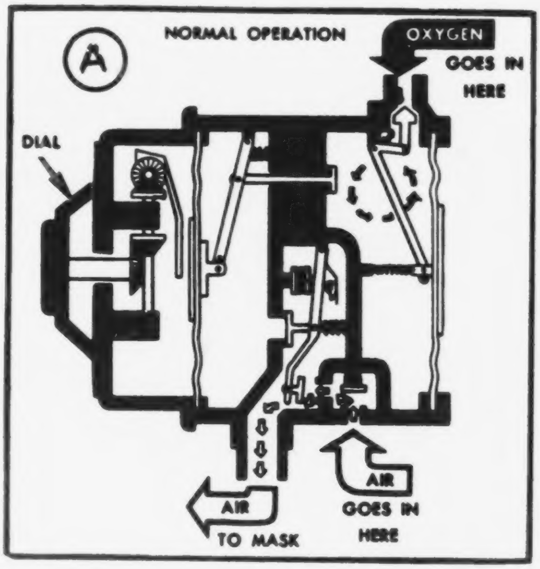

②
OXYGEN
GOES IN
HERE
OXYGEN
GOES TO
MASK

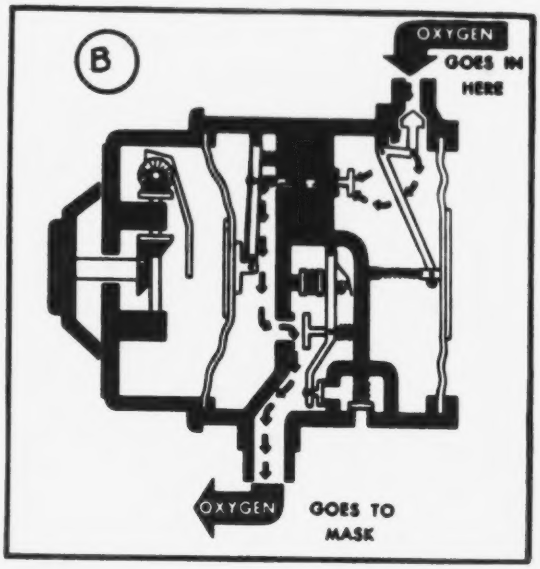

③
OXYGEN
GOES IN
HERE
OXYGEN
GOES TO
MASK


④
OXYGEN
GOES IN
HERE
R-503

No Response Required

Frame 7


A
NORMAL OPERATION
OXYGEN
GOES IN HERE
DIAL
AIR
TO MASK
AIR
GOES IN HERE


B
OXYGEN
GOES IN HERE
OXYGEN
GOES TO MASK

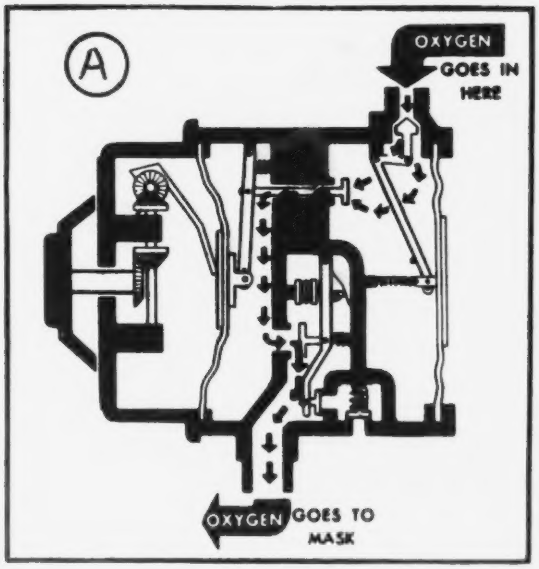
Place the letter of the sketch in the blank space next to the situation it matches.

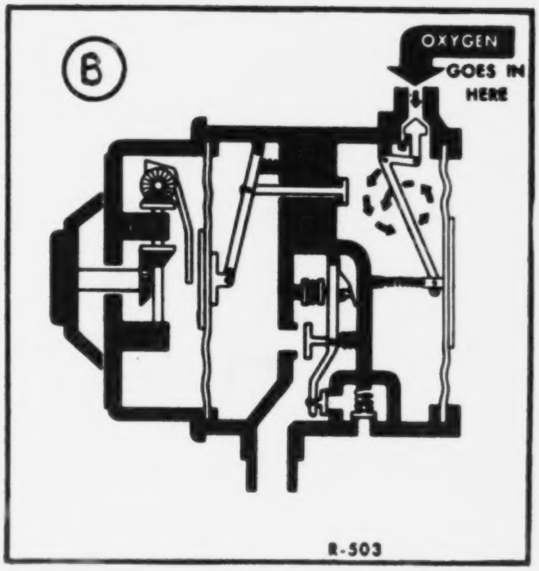
_____1. You will only breathe air because the air valve is open and the oxygen valve is closed.

_____2. The regulator will provide you with 100% oxygen because the air valve is closed and the oxygen valve is open.

Answers to Frame 7: 1. A 2. B

Frame 8


A
OXYGEN GOES IN HERE
OXYGEN GOES TO MASK


B
OXYGEN GOES IN HERE
R-503

Place the letter of the sketch in the blank space next to the situation it matches.

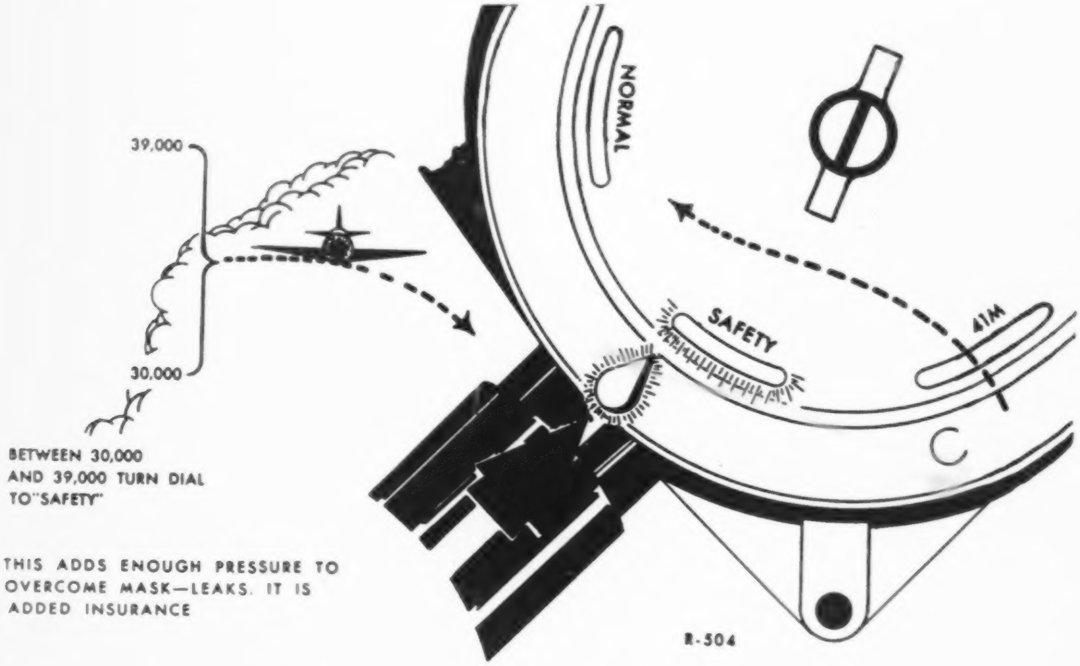
_____1. As you breathe out you push the diaphragm against the spring tension. This in turn closes the demand valve and stops the flow of oxygen to the mask.

_____2. When you inhale the spring pushes against the diaphragm. The diaphragm opens the demand valve and oxygen is forced into the mask.

Answers to Frame 8: B 1. A 2.

Frame 9

As has been said, the "normal" setting on the A-14 is used up to 30,000 feet and when the system is not being used the regulator must be left in this position. From 30,000 feet to 39,000 feet, the user should select the SAFETY setting on the dial. As explained below, this is added insurance against hypoxia which can creep up on you. The SAFETY setting provides only .04 psi to the mask.


NORMAL
39,000
30,000
SAFETY
41M
BETWEEN 30,000 AND 39,000 TURN DIAL TO "SAFETY"
THIS ADDS ENOUGH PRESSURE TO OVERCOME MASK—LEAKS. IT IS ADDED INSURANCE
R-504

Use of the Safety Setting on Type A-14 Oxygen Regulators.

Check the following statements that are true.

_____1. The SAFETY setting on the A-14 is used between 30,000 and 39,000 feet.

_____2. The SAFETY is used in case of an emergency.

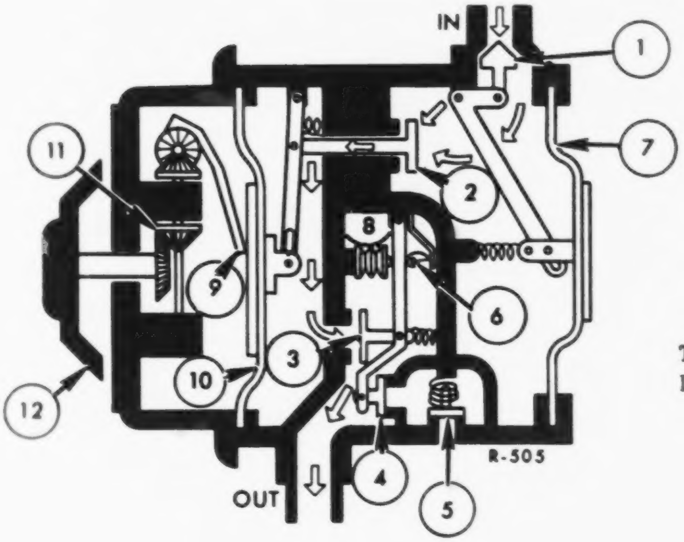
_____3. Hypoxia can creep up on you at high altitudes.

_____4. When left in NORMAL, the regulator will not drain the system.

Answers to Frame 9: ✓ 1. _____ 2. ✓ 3. ✓ 4.

Frame 10

Keep in mind that without the pressure breathing mechanism, the A-14 will work the same as the A-12A regulator. The oxygen is reduced in the first stage chamber to 40 to 60 psi by the pressure reducing valve (1) and the diaphragm (7). The demand valve (2) is still controlled by the demand diaphragm just the same as in the A-12A. The oxygen pressure in the second stage chamber can be controlled in two ways. At low altitude it will be the same as the cabin pressure on top of the demand diaphragm and during pressure breathing it will be controlled by the spring tension of the pressure breathing lever (9). Remember, the air for dilution is still controlled by the diluter lever which works the diluter cam (6) and by the aneroid (8).



Type A-14 Pressure Demand Oxygen Regulator.

Place the number(s) of the component in the blank next to the statement that best describes its operation/use.

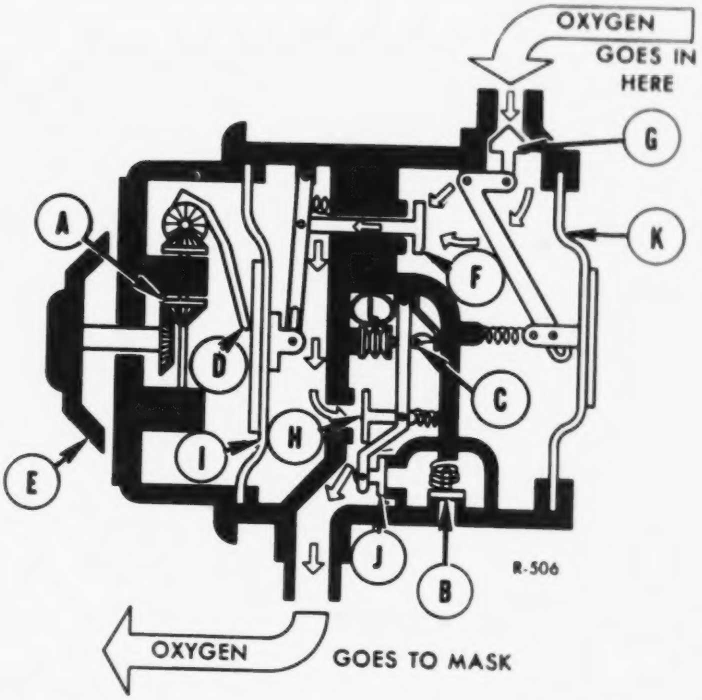
_____a. Controlled by the demand diaphragm.

_____b. Spring tension of this lever will control the oxygen pressure in the second stage chamber during pressure breathing.

_____c. This part and the diluter lever control the air for dilution.

Answers to Frame 10: __2__ a. __9__ b. __8__ c.

Frame 11



Place the letter(s) of the part in the blank space next to the statement that describes its operation/use. Some statements require more than one answer.

_____1. Reduces oxygen pressure in the first stage chamber to 40 to 60 PSI.

_____2. In the 100% oxygen position the diluter control cam presses down on a metal strip attached to a common lever to close this valve.

_____3. When you inhale, this spring puts a force on the demand diaphragm and opens the demand valve.

_____4. The diluter lever works this item.

_____5. This item will control the air flow to the mask up to 32,000 feet with the diluter lever in the normal position.

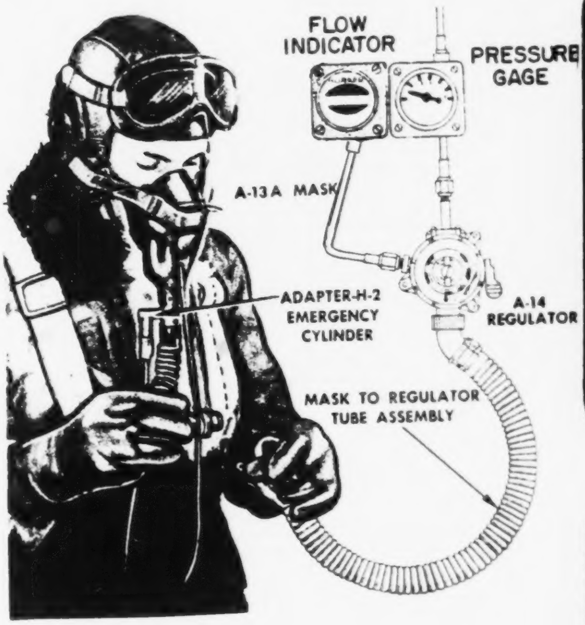
_____6. Exhaling will force this diaphragm against the spring tension on the pressure breathing lever and close the demand valve.

_____7. To breathe 100% oxygen these valves must be open.

Answers to Frame 11: G, K 1. J 2. D 3. C 4. L 5.
I 6. F, H 7.

Frame 12

Before we go to the next regulator that has a pressure gage and a flow indicator built in, we should say here that with the A-14, the A-3 flow indicator, and the K-1 pressure gage are the same ones as used with the A-12A. If you recall, in the past lesson we said that the K-1 pressure gage is bourdon tube operated and shows cylinder pressure. The A-3 flow indicator (blinker) lets the user know that oxygen is flowing through the regulator by a blinking action.


FLOW INDICATOR
PRESSURE GAGE
A-13A MASK
ADAPTER-H-2 EMERGENCY CYLINDER
A-14 REGULATOR
MASK TO REGULATOR TUBE ASSEMBLY

100
200
300
400
FULL
500
LBS PER SQ IN
OXYGEN CYL. PRESSURE

K-1 Pressure Gage.

BLINKER
OXYGEN FLOW INDICATOR

A-3 Flow Indicator.

Check the following statements that are true.

_____ 1. The K-1 pressure gage and A-3 flow indicator are used with the A-12A and A-14 regulators.

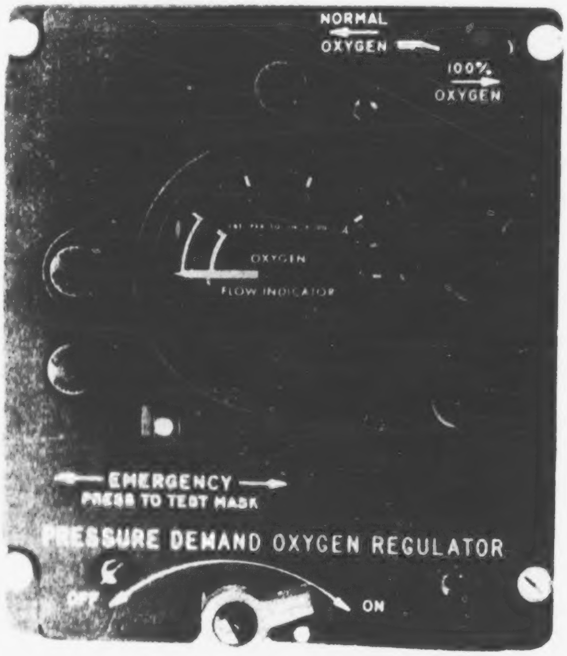
_____ 2. All oxygen regulators require a separate pressure gage.

_____ 3. The K-1 pressure gage is bourdon tube operated.

Answers to Frame 12: ✓ 1. ____ 2. ✓ 3.

Frame 13

As was said in the past, there are many models of that same oxygen regulator. The D-2A regulator, shown below, is also a pressure demand regulator with many changes over the A-14. The change that is most easily seen from looking at the face of the D-2A is that the pressure gage and the flow indicator have been added to it. Now note that no pressure control dial is seen so this shows that the D-2a will automatically deliver the right pressure as altitude changes. This is done with an aneroid. The D-2A regulator also has an ON-OFF supply switch (lower center) that shuts off the oxygen supply to the regulator when it is not being used. The D-2A is placed on a panel in the aircraft and the A-12A and A-14 are hooked in the oxygen lines.


NORMAL
OXYGEN
100%
OXYGEN
OXYGEN
FLOW INDICATOR
EMERGENCY
PRESS TO TEST MASK
PRESSURE DEMAND OXYGEN REGULATOR
OFF
ON

Type D-2A Oxygen Regulator.

Complete the following statements.

1. The D-2A oxygen regulator has a built-in pressure gage and __________ __________.

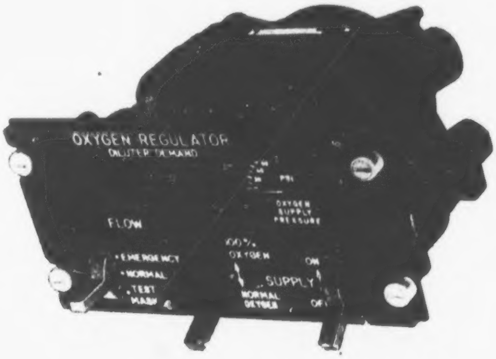
2. Inside of the D-2A regulator is an __________ that will automatically deliver the right pressure as the altitude changes.

3. The D-2A is mounted __________ __________ __________ in the aircraft while the __________ and __________ are connected into the oxygen line.

Answers to Frame 13: 1. flow indicator 2. aneroid
3. on a panel, A-12A, A-14

Frame 14

The MD-1 pressure demand regulator, shown below, is very much like the D-2A but has a lot of improvements. The compact design needs about half of the panel space to mount in and presents the user with a much more uniform and readable system of controls. This regulator is used more at the present time than any other regulator because it can be adapted to more systems in use. For high altitude flights this is the best regulator available at the present time. In the illustration, look at the three toggle switches that are used to control this regulator. The EMERGENCY toggle (left) has three positions: emergency (up), normal (center), and test mask (down). The DILUTER toggle (center) has two positions: 100% and normal. The SUPPLY toggle is simply on or off. The FLOW indicator is the "flag" type which is worked by a diaphragm. The pressure gage shows system pressure or pressure before it is reduced for breathing.



Type MD-1 Automatic Diluter Demand Pressure
Breathing Oxygen Regulator.

Check the following statements that are true.

_____1. The MD-1 has three toggle switches for control.

_____2. The MD-1 is used more than other regulators at present.

_____3. The MD-1 is twice as large as the D-2A regulator.

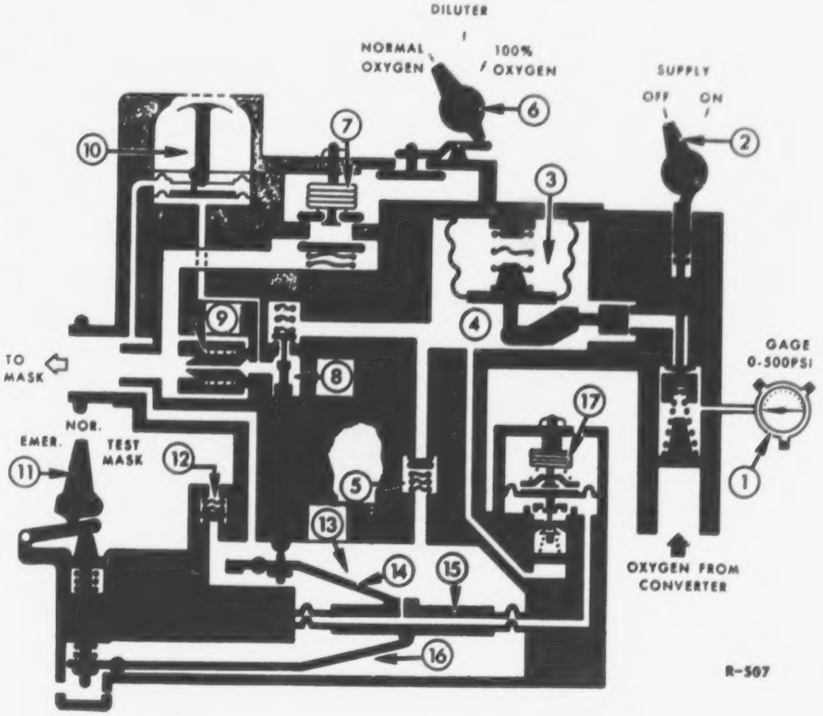
_____4. The emergency toggle has three positions.

_____5. The flow indicator operates from a diaphragm.

Answers to Frame 14: ✓ 1. ✓ 2. ___3. ✓ 4. ✓ 5.

Frame 15

Let's take a look at the major parts inside the MD-1 before we talk about how it operates. Mentally match each numbered item in the schematic below with its name from the list below.

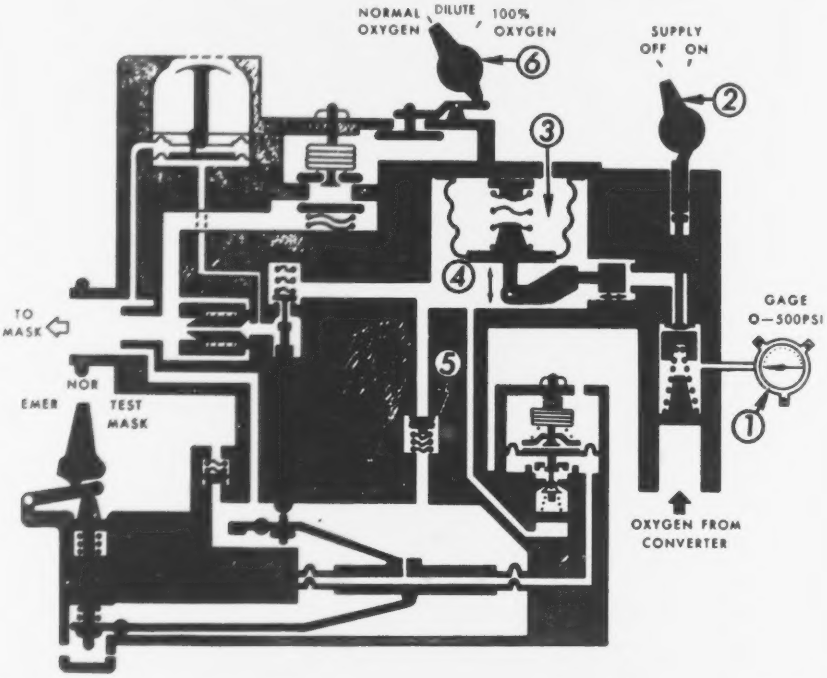

DILUTER
NORMAL OXYGEN
100% OXYGEN
SUPPLY
OFF
ON
GAGE 0-500PSI
TO MASK
NOR.
EMER.
TEST MASK
OXYGEN FROM CONVERTER
R-507
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17

1. Pressure Gage
2. Supply Toggle
3. Press. Reducing Mechanism
4. 1st Stage Chamber
5. 1st Stage Relief Valve
6. Diluter Toggle
7. Diluter Aneroid
8. Demand Valve
9. Injector Mechanism
10. Flow Indicator
11. Emergency Toggle
12. 2nd Stage Relief Valve
13. 2nd Stage Chamber
14. Demand Valve Lever
15. Demand Diaphragm
16. Counter-Weight Lever
17. Press. Breathing Aneroid

No Response Required

Frame 16

Some of the parts of the MD-1 have, in the past, been pointed out to you. The pressure gage (1) shows system (or supply) pressure. The supply toggle switch (2) just lets oxygen in the regulator when it is placed in "ON." The pressure reducing mechanism (3) is the first stage of reducing. This is a spring loaded bellows and valve which sets the incoming pressure between 37 and 45 psi. As the bellows moves up and down, the valve moves back and forth (see arrows). The reducing mechanism is in the first stage chamber (4). The first relief valve (5) will open at 55 psi if the reducing mechanism fails. The diluter toggle switch (6) lets cabin air in to mix with the oxygen when it is in the "normal oxygen" position and the air inlet valve is in the "100% oxygen" position.



Match the circled number of the component in the schematic to the statement below that describes that component operation/use.

_____ a. Opens a valve that allows oxygen from a converter into the regulator.

_____ b. When put into the normal position it lets cabin air mix with the oxygen and dilute it.

_____ c. A high incoming oxygen pressure will affect a spring-loaded bellows in this mechanism which in turn will set the incoming pressure between 37 to 45 psi.

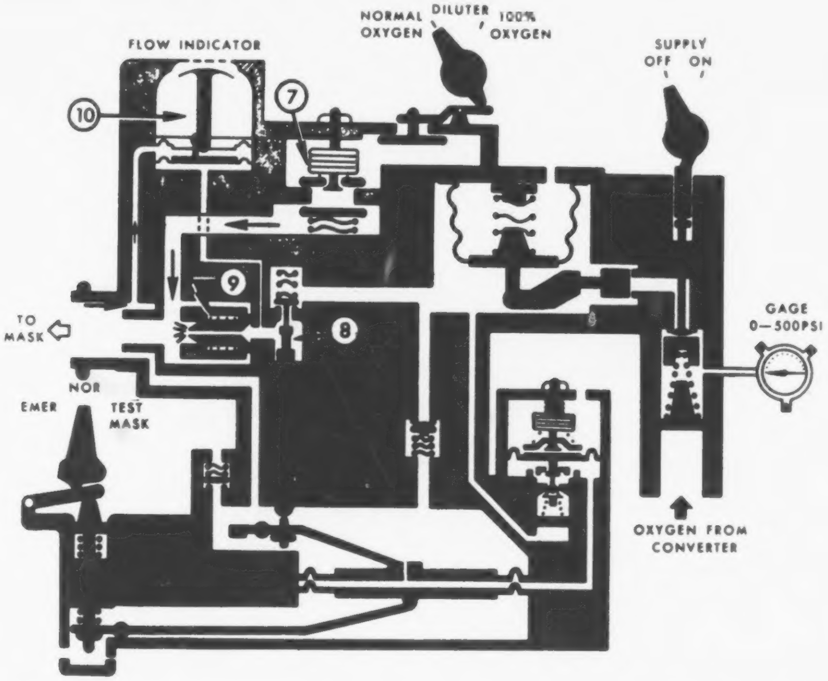
_____ d. A spring loaded valve that will open at 55 psi if the pressure reducing valve failed.

_____ e. Shows the oxygen pressure in the system (supply pressure).

Answers to Frame 16: 2 a. 6 b. 3 c. 5 d. 1 e.

Frame 17

The diluter aneroid (7) lets air in according to the cabin altitude when the diluter toggle switch is in the "normal oxygen" position. The aneroid will expand and completely shut off the air at 33,000 feet cabin altitude. The demand valve (8) lets the oxygen into the injector assembly (9) which acts as a venturi (creates a low pressure area). This low pressure area draws air in to mix with the oxygen. If a large demand is placed on the regulator, the injector (9) will slide forward (to the left) and let oxygen bypass through the passageway on each side. The flow indicator (10) is a "flag" which is diaphragm-operated and shows in the viewing window as the user breathes.



Place the number of the component from the above schematic in the blank alongside the statement that best describes its operation/use. Some numbers can be used more than once.

_____a. Cabin atmospheric pressure will cause this unit to expand.

_____b. Creates a low pressure area that draws air in to mix with the oxygen.

_____c. The amount of oxygen that flows into the injector is controlled by this unit.

_____d. Meters air according to the cabin altitude completely shutting off the air flow when the cabin altitude reaches 33,000 feet.

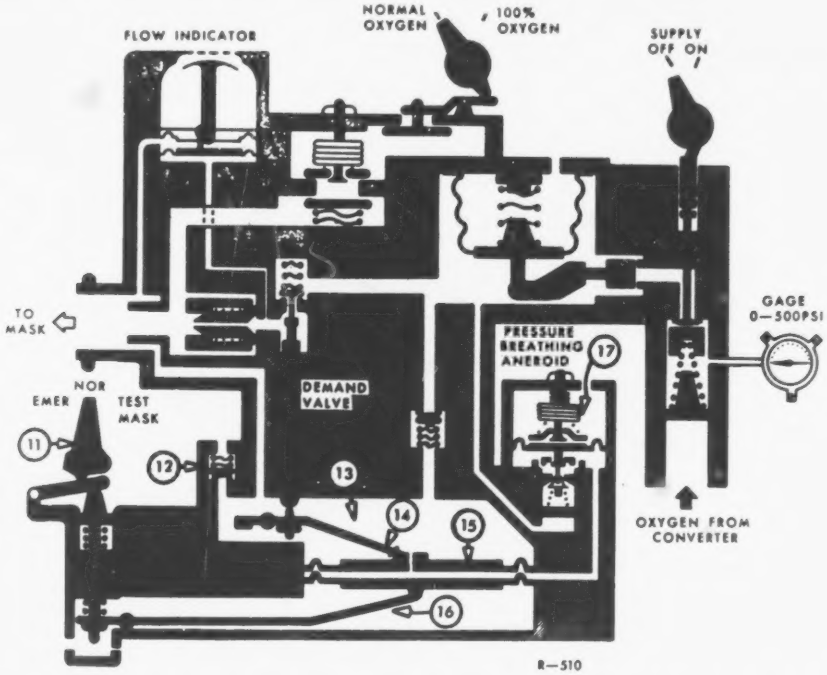
_____e. Operated by a diaphragm to show the flow of oxygen each time the user inhales.

_____f. Slides forward when a high demand is placed on the regulator to let oxygen bypass through passageways in each side of it.

Answers to Frame 17: 7 a. 9 b. 8 c. 7 d. 10 e.
9 f.

Frame 18

The emergency toggle switch (11) gives pressure breathing at any altitude when it is put in "EMER." In the n"normal" position, pressure breathing is taken care of by the pressure breathing aneroid (17). The "test mask" position provides pressure for testing the mask for leaks while on the face. The second stage relief valve (12) relieves pressure above 1.5 inches of water pressure in the second stage chamber (13). The demand valve lever (14) is hooked, at one end, to the demand diaphragm. It will push the demand valve found on the other end of the lever up and down. The counterweight lever (16) provides a linkage to the emergency toggle switch. It stops the fluctuation of pressure in the second stage chamber. The pressure breathing aneroid (17), which was mentioned earlier, automatically increases the pressure load on the demand diaphragm as the aircraft altitude increases. This, in turn, increases the pressure sent to the mask.


NORMAL OXYGEN
100% OXYGEN
FLOW INDICATOR
SUPPLY
OFF ON
TO MASK
GAGE 0—500PSI
PRESSURE BREATHING ANEROID
17
DEMAND VALVE
NOR
EMER
TEST MASK
11
12
13
14
15
16
OXYGEN FROM CONVERTER
R—510

Place the number of the part from the above sketch in the blank space alongside the statement that best describes its operation/use. Some numbers can be used more than once.

_____ a. In the normal position aircraft altitude will cause this unit to expand and increase the pressure load on the demand diaphragm which, in turn, will increase the pressure sent to the mask.

_____ b. Provides a linkage from the demand diaphragm to the emergency toggle switch.

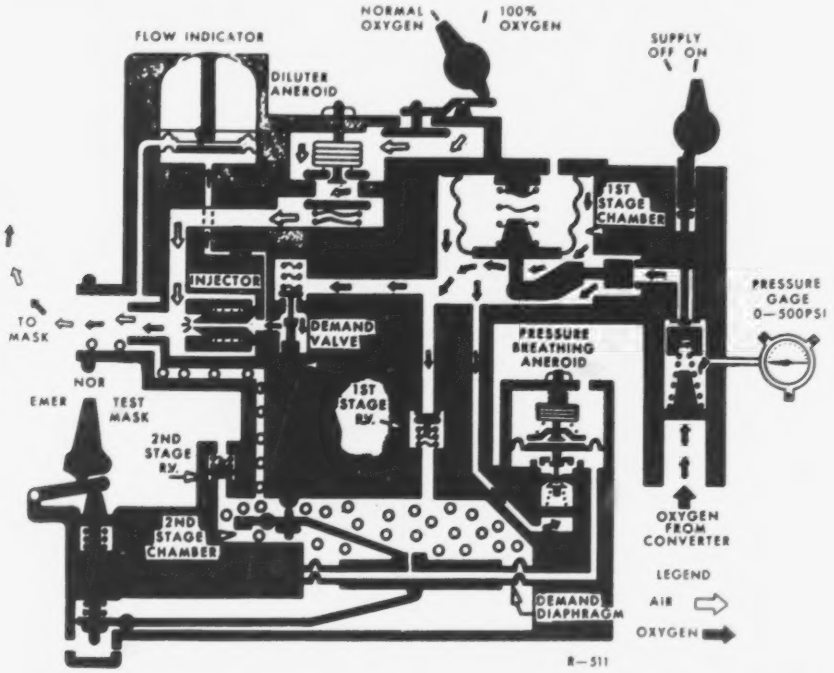
_____ c. When moved by the demand diaphragm, moves the demand valve up or down to increase or decrease the pressure sent to the mask.

_____ d. When placed in the emergency position it will provide pressure breathing at any altitude

Answers to Frame 18: 17 a. 16 b. 14 c. 11 d.

Frame 19

In the sketch shown you can see how the MD-1 works below 30,000 feet when the user inhales or calls for oxygen. Follow the flow of oxygen and air through the regulator as we talk about how it works. With the supply toggle switch "ON," oxygen goes to the first stage chamber where the pressure is dropped to 37 to 45 psi. Oxygen now goes down to the small chamber below the pressure breathing aneroid. The aneroid has not expanded and the diaphragm under the aneroid has this port closed. When the user inhales, a vacuum is formed in the second stage chamber (shown by the circles) that will raise the demand diaphragm and the demand lever which, in turn, opens the demand valve. Oxygen will now flow through the top of the demand valve and through the injector, which will cause a low pressure area and draw in air from around the diluter aneroid. Oxygen also goes up to the flow indicator diaphragm and pushes the flag up to the window. The air and oxygen now mix in front of the injector and flow to the mask.


NORMAL OXYGEN
100% OXYGEN
FLOW INDICATOR
SUPPLY
OFF ON
DILUTER ANEROID
1ST STAGE CHAMBER
PRESSURE GAGE 0—500PSI
INJECTOR
DEMAND VALVE
TO MASK
PRESSURE BREATHING ANEROID
NOR
EMER
TEST MASK
1ST STAGE R.V.
2ND STAGE R.V.
2ND STAGE CHAMBER
OXYGEN FROM CONVERTER
LEGEND
AIR
OXYGEN
DEMAND DIAPHRAGM
R-511

Select the statements that describe the operation of the MD-1 oxygen regulator. (Circle the number(s) of your choice.)

1. As you inhale the demand diaphragm will rise and open the demand valve and let oxygen from the converter flow through the injector.

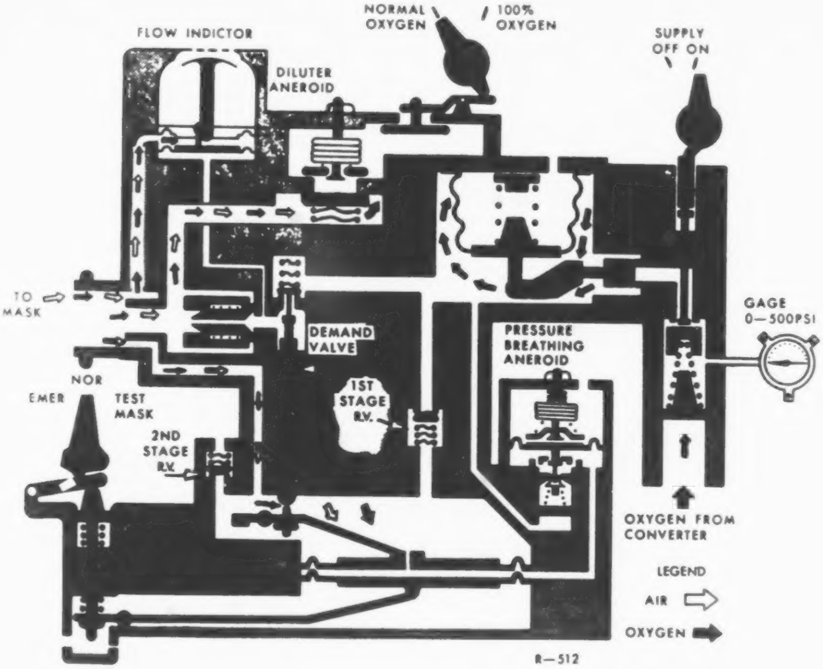
2. The oxygen that flows through the injector will create a low pressure area that will draw in air from around the diluter aneroid and mix it with the oxygen.

3. For items 1 and 2 above to happen the supply toggle is in the "ON" position, diluter toggle is in "normal oxygen," the emergency toggle is in "NOR," and the aircraft must be below 30,000 feet.

Answers to Frame 19: ① ② ③

Frame 20

Let's take a look at what goes on in the regulator when the user exhales or breathes out. Muscular effort on the part of the user is needed to overcome the pressure in the regulator. This is especially true if the pressure breathing aneroid is in operation. When the user breathes out hard enough, the demand diaphragm drops down and lets the demand valve go closed. This back pressure also closes the air check valve below the diluter aneroid. Pressure on the top side of the flow indicator diaphragm pulls the flag out of the window. Oxygen pressure will quickly build up in the first stage chamber and close the reducing valve. When the user inhales again, this pressure is reversed as was explained in the previous frame.


NORMAL OXYGEN
100% OXYGEN
FLOW INDICTOR
DILUTER ANEROID
SUPPLY
OFF ON
TO MASK
GAGE 0—500PSI
DEMAND VALVE
PRESSURE BREATHING ANEROID
NOR
EMER
TEST MASK
1ST STAGE R.V.
2ND STAGE R.V.
OXYGEN FROM CONVERTER
LEGEND
AIR
OXYGEN

R—512

Select the true statements from the following. (Circle the number(s) of your choice.)

1. When the user exhales, the flow indicator flag is not visible.

2. Muscular effort is required when exhaling into the regulator.

3. When exhaling, the demand diaphragm drops and closes the demand valve.

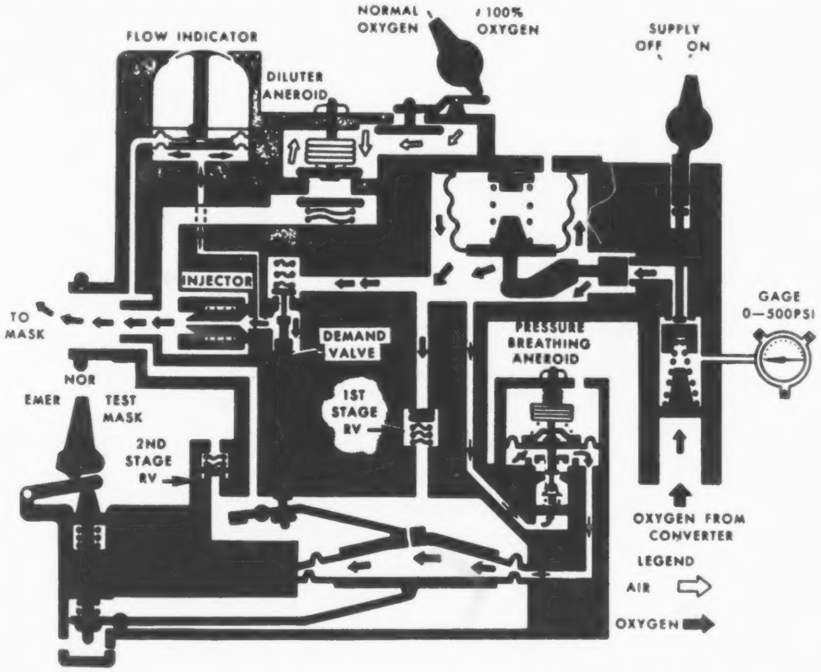
4. The diluter toggle must be in 100% oxygen to get air in the regulator.

5. The first-stage chamber reduces pressure to between 37 and 45 psi.

Answers to Frame 20: [✓ 1.] [✓ 2.] [✓ 3.] 4. [✓ 5.]

Frame 21

Now, let's talk on how the MD-1 regulator works when pressure breathing. As we have said, pressure to the mask is changed automatically by the pressure breathing aneroid as cabin pressure goes up. A safety pressure of 0.1 to 0.2 inches of water is sent to the mask at altitudes of 30,000 to 39,500 feet to do away with the chance of a negative pressure at the mask. Near 40,000 feet, the pressure breathing aneroid has expanded to give automatic pressure breathing to the user. This pressure is from 2 to 15 inches of water pressure depending on cabin altitude. You can see in the sketch shown that oxygen from the pressure breathing aneroid has raised the demand diaphragm which now holds the demand valve open. The cycle shown is when the user is breathing in. To exhale, the user has to overcome the pressure on the demand diaphragm. See, too, that the diluter aneroid has closed the air inlet and the flow indicator flag can be seen in the window.


FLOW INDICATOR
NORMAL OXYGEN
100% OXYGEN
SUPPLY
OFF ON
DILUTER ANEROID
INJECTOR
TO MASK
DEMAND VALVE
PRESSURE BREATHING ANEROID
GAGE 0—500PSI
NOR
EMER
TEST MASK
1ST STAGE RV
2ND STAGE RV
OXYGEN FROM CONVERTER
LEGEND
AIR ⇨
OXYGEN ➡

t—513

Select the statements that describe the operation of the MD-1 regulator during pressure breathing. (Circle the number(s) of your choice.)

1. At altitudes of 30,000 to 39,500 feet a safety pressure of 0.1 to 0.2 inches of water is sent to the mask to do away with the chance of a negative pressure at that point.

2. Around 40,000 feet the pressure breathing aneroid has expanded and raised the demand diaphragm which, in turn, holds the demand valve open.

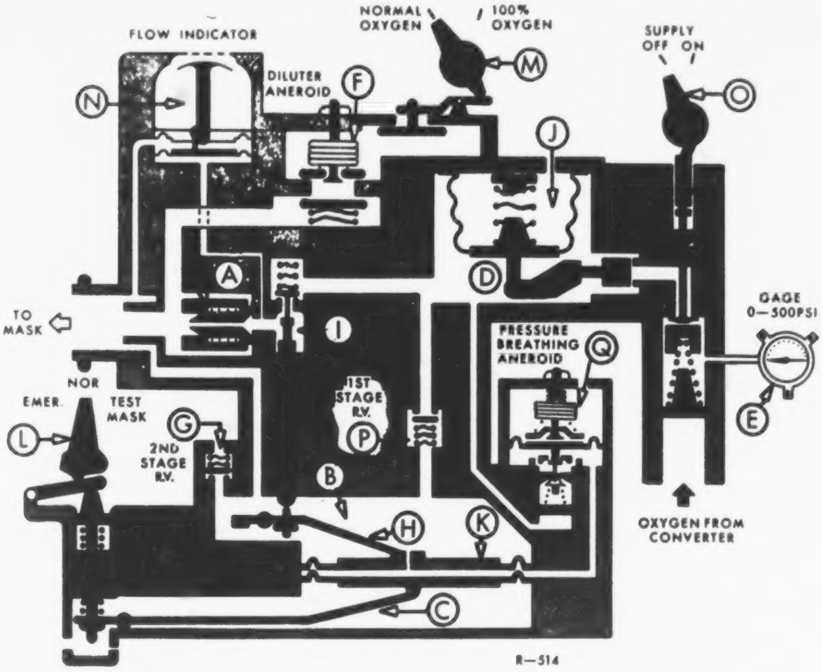
3. To exhale you have to overcome the pressure applied to the demand diaphragm.

Answers to Frame 21: ①. ②. ③.

Frame 22

INSTRUCTIONS

Identify the components of the MD-1 oxygen regulator by matching the letters in the arrowed circles with the name of the item below.

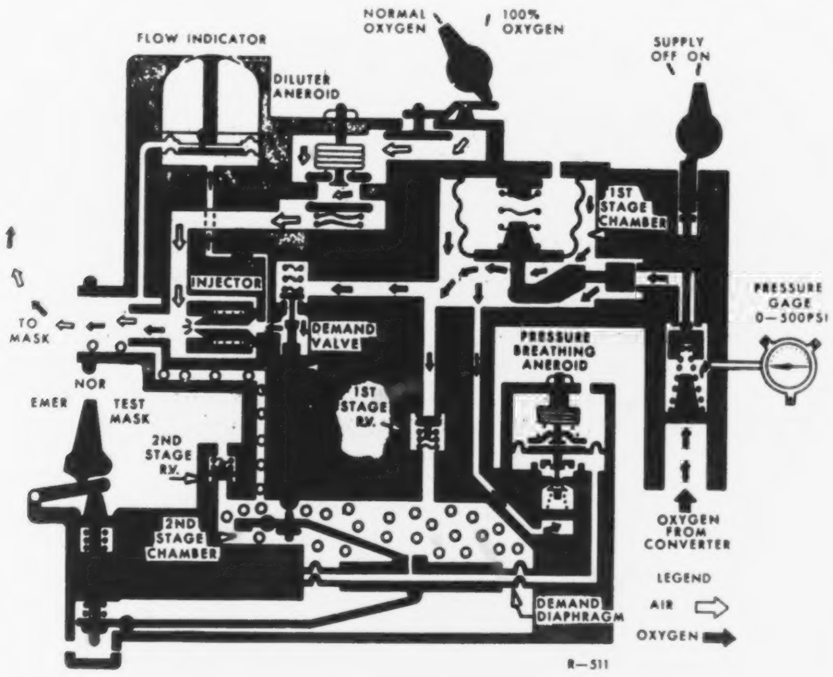

FLOW INDICATOR
NORMAL OXYGEN
100% OXYGEN
SUPPLY
OFF ON
DILUTER ANEROID
F
M
O
N
J
A
D
I
TO MASK
GAGE 0—500PSI
PRESSURE BREATHING ANEROID
Q
NOR
EMER.
TEST MASK
G
L
2ND STAGE R.V.
1ST STAGE R.V.
P
B
E
H
K
OXYGEN FROM CONVERTER
C
R—514

______1. Pressure Gage
______2. Supply Toggle
______3. Pressure Reducing Mechanism
______4. 1st Stage Chamber
______5. 1st Stage Relief Valve
______6. Diluter Toggle
______7. Diluter Aneroid
______8. Demand Valve
______9. Injector Mechanism

______10. Flow Indicator
______11. Emergency Toggle
______12. 2nd Stage Relief Valve
______13. 2nd Stage Chamber
______14. Demand Valve Lever
______15. Demand Diaphragm
______16. Counter-Weight Lever
______17. Pressure Breathing Aneroid

Answers to Frame 22:
E 1. O 2. J 3. D 4. P 5.
M 6. F 7. I 8. A 9. N 10.
L 11. G 12. B 13. H 14. K 15.
C 16. Q 17.

Frame 23


NORMAL OXYGEN
100% OXYGEN
FLOW INDICATOR
SUPPLY
OFF ON
DILUTER ANEROID
1ST STAGE CHAMBER
INJECTOR
DEMAND VALVE
PRESSURE GAGE 0—500PSI
PRESSURE BREATHING ANEROID
TO MASK
NOR
EMER
TEST MASK
1ST STAGE R.V.
2ND STAGE R.V.
2ND STAGE CHAMBER
OXYGEN FROM CONVERTER
LEGEND
AIR
OXYGEN
DEMAND DIAPHRAGM
R—511

Select the statements that describe the operation of the MD-1 regulator below 30,000 feet. (Circle the number(s) of your choice.)

1. Both the pressure breathing aneroid and diluter aneroid are compressed.

2. The pressure breathing aneroid expands while the diluter aneroid is compressed.

3. With the supply toggle in "ON," oxygen goes to the first stage chamber where it is reduced to 37 to 45 psi.

4. When you inhale a vacuum is formed in the second stage chamber that raises the demand diaphragm and opens the demand valve.

5. Oxygen will flow through the injector which creates a low pressure area that draws air in through the diluter aneroid valve.

6. Both the oxygen from the injector and the air from the diluter aneroid mix and flow to the mask.

7. As you inhale a pressure is placed on the demand diaphragm forcing the demand diaphragm to close the demand valve.

8. As you inhale a pressure is placed on the top of the flow indicator diaphragm which pulls the flag out of the window.

Select the statements that describe the operation of the MD-1 regulator during pressure breathing. (Circle the number(s) of your choice.)

9. The diluter aneroid will expand as the aircraft rises in altitude closing the diluter valve.

10. The diluter aneroid will send a safety pressure of 0.1 to 0.2 inches of water to the mask at altitudes of 30,000 to 39,000 feet.

11. Near 40,000 feet, the pressure breathing aneroid has expanded and provides oxygen pressure to the mask equivalent to 2 to 15 inches of water pressure.

12. The pressure breathing aneroid supplies oxygen pressure to raise the demand diaphragm and close the demand valve.

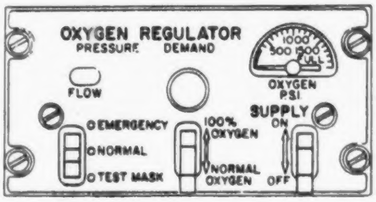
13. During pressure breathing a person cannot exhale.

14. When oxygen pressure is supplied to the mask it also is placed on the bottom of the flow indicator diaphragm raising the flag in the window.

Answers to Frame 23: [✓ 1.] 2. [✓ 3.] [✓ 4.] [✓ 5.] [✓ 6.] 7. 8.
[✓ 9.] 10. [✓ 11.] 12. 13. [✓ 14.]

Frame 24

The oxygen regulators that are used in high pressure gaseous oxygen systems (1,800 to 1,850 psi) where a pressure reducer is not installed between the cylinders and the regulator are the MD-2 and MB-2 pressure demand regulators. If a pressure reducer is installed, regulators such as the MD-1 and D-2A can be used. The principles of operation of the MD-2 and MB-2 are the same as the MD-1. However, these regulators are constructed internally to withstand high pressure. The MD-2 shown (note the high pressure gage) looks the same as the MD-1 but the two regulators cannot be interchanged.


OXYGEN REGULATOR
PRESSURE DEMAND
1000
500
1500
FULL
OXYGEN PSI
FLOW
SUPPLY
ON
OFF
EMERGENCY
NORMAL
TEST MASK
100% OXYGEN
NORMAL OXYGEN

MD-2 Oxygen Regulator

Check the following statements that are true.

______1. The MD-2 and MB-2 are high-pressure regulators.

______2. The D-2A regulator is designed to withstand high pressure.

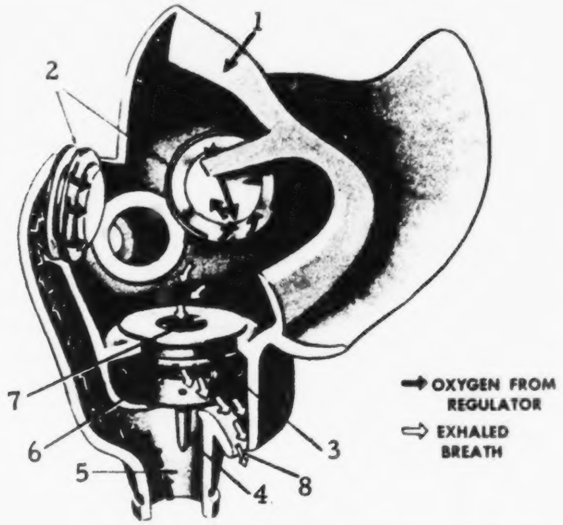
______3. The MD-2 is a pressure demand regulator.

______4. If a pressure reducer is installed between the high pressure cylinders and the regulator, it's possible to use the D-2A.

Answers to Frame 24: __✓__1. _____2. __✓__3. __✓__4.

Frame 25

The pressure demand mask, type A-13 and type A-13A, are used with the pressure demand oxygen system. Pressure demand masks are not like demand masks in that they will hold pressures higher than ambient pressure. A flap or seal made of rubber (1) forms a ring on the inside of the mask to keep the oxygen in the mask. Check valves (2) keep the oxygen inlets closed while the user is exhaling. The exhalation valve (3) opens only at a pressure just a little more than that on the inside of the tubing leading to the mask. The housing of the exhalation valve forms a tube which goes down into the inlet tube (5). Through this tube, the oxygen coming in sends its delivery pressure to act upon the lower side of the compensating diaphragm (6). This pressure keeps the exhalation valve (3) closed until a little greater pressure caused by exhaling is brought to bear upon the upper surface of the main diaphragm (7). The valve then opens and the exhaled air leaves the mask through the port (8). The mask-to-regulator hose in the pressure demand system is the same as in the demand system.



Type A-13 Pressure Demand Mask.

Place the number from the sketch shown above in the blank alongside the statement that best describes the mask's operation/use.

_____a. Will open when the user inhales and closes when the user exhales.

_____b. Will stay closed until a little greater pressure caused by exhaling is placed on the upper surface of the main diaphragm at which time it will open.

_____c. Exhaled air will leave through this port.

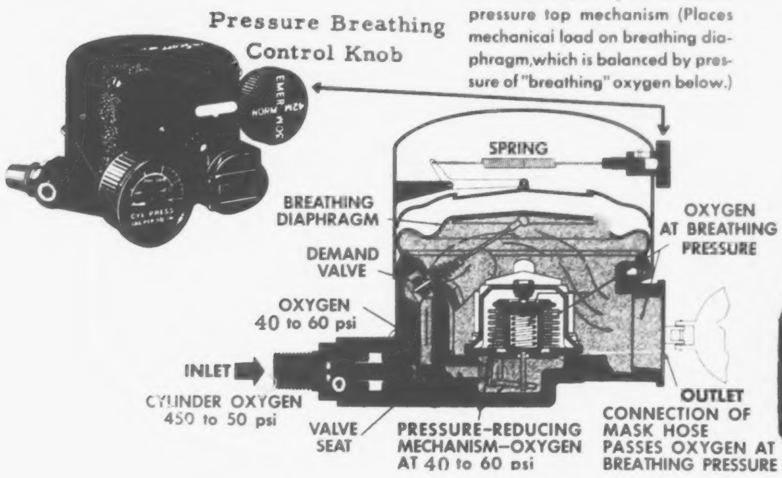
Answers to Frame 25: __2__ a. __3__ b. __8__ c.

Frame 26

The portable pressure demand unit is shown below. It consists of the A-21 regulator and the A-6 cylinder. The pressure demand unit is installed in the larger aircraft with an operating range above 35,000 feet. The A-21 is a straight demand regulator (no air) and contains a bellows-operated pressure reducer. Pressure breathing is caused by turning the control knob which puts a load on the breathing diaphragm through a system of springs and levers (very much like the A-14). The control knob has four (4) settings: "NORMAL" (demand only, no pressure), "30M" (pressure breathing at 30,000 feet), "42M" (pressure breathing at 42,000 feet), and "EMERGENCY" (continuous flow of oxygen to the user).

type A-21

PRESSURE-BREATHING REGULATOR


Pressure Breathing Control Knob
EMER
NORM
42M
30M
CYL PRESS
SPRING
BREATHING DIAPHRAGM
DEMAND VALVE
OXYGEN 40 to 60 psi
INLET
CYLINDER OXYGEN 450 to 50 psi
VALVE SEAT
PRESSURE-REDUCING MECHANISM—OXYGEN AT 40 to 60 psi
OXYGEN AT BREATHING PRESSURE
OUTLET
CONNECTION OF MASK HOSE PASSES OXYGEN AT BREATHING PRESSURE

Schematic shows operation of the pressure tap mechanism (Places mechanical load on breathing diaphragm, which is balanced by pressure of "breathing" oxygen below.)

BREATHI
OXYGE

Pressure Demand Portable Unit

Check the following statements that are true.

_____1. The A-21 is a pressure demand portable regulator.

_____2. The A-6 cylinder is used with the A-21 regulator.

_____3. Pressure breathing is controlled by an aneroid in the A-21.

Answers to Frame 26: __✓__ 1. __✓__ 2. _____ 3.

PROGRAMMED TEXT
C3ABR42331-PT-402

Technical Training

Aircraft Environmental Systems Mechanic

LIQUID OXYGEN SYSTEMS

18 April 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE.
DO NOT USE ON THE JOB.

RGL: 10.1

OBJECTIVES

State general principles relating to the operation of a liquid oxygen system. A minimum of four out of five must be correct.

INSTRUCTIONS

As you read and study each frame in this programmed text, locate the individual component or system being discussed in the classroom or lab. A better understanding of the system will result if you look at and inspect these units as you read about them. Check with your instructor if these components are not available.

After each frame in the programmed text, you will find a number of statements and you are asked to select the true statement or statements from this list. Read the material carefully before making a selection, answers will be found two frames over at the bottom of the page. If you select the correct answer(s) continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before continuing. Check with your instructor if you have any problems.

Supersedes 3ABR42331-PT-401B, 17 March 1981; 3ABR42331-PT-401C, 2 March 1981; 3ABR42331-PT-401D, 2 March 1981; 3ABR42331-PT-402A, 26 February 1981; 3ABR42331-PT-402B, 23 February 1981; 3ABR42331-PT-402C, 26 February 1981.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Introduction

The liquid oxygen (LOX) system, which will be discussed in this text, is the source of gaseous oxygen for the crew.

While the low pressure and high pressure gaseous systems are still being used on Air Force aircraft, these systems are gradually being changed to the liquid oxygen system. Since inflight refueling was introduced, an aircraft can fly for long periods of time. The pilot and crew need large amounts of oxygen. The low pressure gaseous cylinders are light but take up a lot of space. The high pressure cylinders take up less space but are heavier. The best choice was to use the LOX system, which saves space and weight. The average weight and space reduction for all aircraft is 74%.

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There are quite a few types of liquid oxygen systems used on Air Force aircraft. The type of system installed in an aircraft will depend upon the aircraft's manufacturer, and its mission. Liquid oxygen converters (containers) used on fighter type aircraft are small, (5 to 10 liter) low pressure 70 psi converters. Because of the size of the crew and the number of passengers, large bomber and cargo aircraft use the larger, (25 to 75 liter), high pressure, 300 psi converters.

NO RESPONSE REQUIRED

Frame 2

LOX (liquid oxygen) is a pale blue, waterlike fluid; its boiling temperature is minus -297°F. This means that at any temperature above -297°F, for instance at -296°F, LOX will boil; changing state from liquid to gas. When liquid oxygen evaporates, it expands to about 860 times its original volume.

When working with LOX you should observe all safety precautions. Never allow LOX to come in contact with your skin. LOX, as we stated earlier, is extremely cold and can cause immediate frostbite (burns). If your skin does come in contact with LOX, you should flush the area with water and see a doctor immediately. Never confine LOX in any other container other than a LOX converter or cryotainer which will be covered in a later frame. The pressure that builds up when the liquid boils off into a gas, will explode most piping, tubing or other non-approved containers.

Check the following statement(s) that are true.

1. ____ At the temperature of -292°F LOX is boiling and changing to a gas.
2. ____ One cubic inch of LOX will expand to 860 cubic inches of gaseous oxygen.
3. ____ LOX may be stored in any metal container.

Frame 3

The liquid oxygen converter assembly (see figure 1) is the main part of a liquid oxygen system. This multi-function unit is designed to receive and store the liquid. It will also allow some liquid to change to a gaseous state. This gaseous oxygen is automatically supplied at a constant pressure to the oxygen regulator for crew use.

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The container is the largest part of the converter assembly. The container is a double walled, vacuumed insulated unit similar to the common "Thermos" bottle. It is also known as a "Dewar" flask after its inventor. As shown (in figure 1) the liquid is stored in the inner shell and a vacuum separates it from the outer shell. The outer shell has a rupture disc installed that will blow out to prevent an explosion; if the inner shell develops a leak, the rupture disc will blow and relieve pressure at 30 psi.

Check the following statement(s) that are true.

1. ____ The liquid oxygen converter assembly supplies liquid oxygen for crew use.

2. ____ The container has a vacuum space that separates the inner and outer shell.

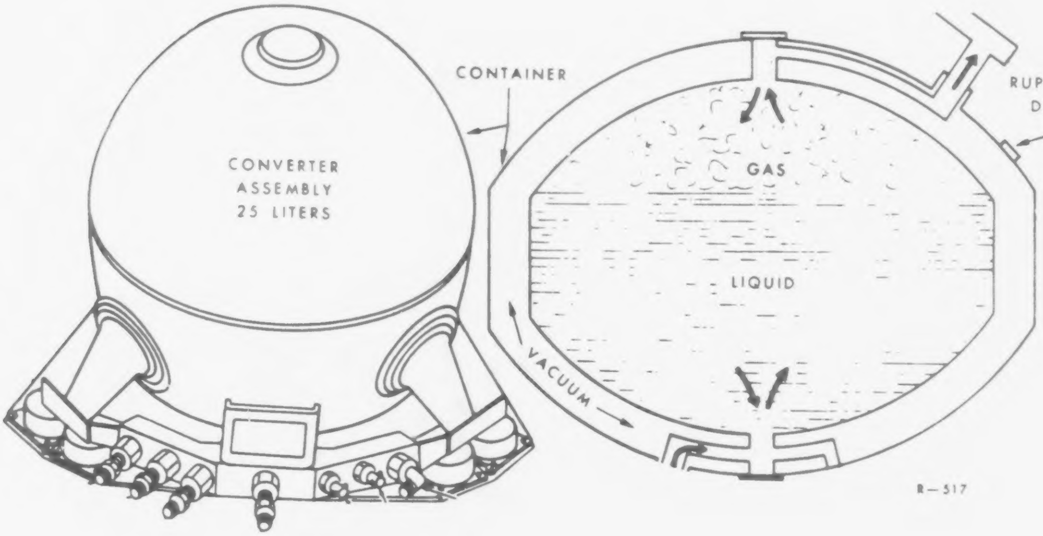

Figure 1.

Answer to Frame 1: NO RESPONSE REQUIRED.

Frame 4

The quantity indicating system is a capacitance contents gage system. This indicating system uses a variable capacitance probe which is located in the liquid container (see figure 2). The probe varies capacitance as the liquid level changes. This varying signal is measured and turned into a liquid level indication by the capacitance gage.

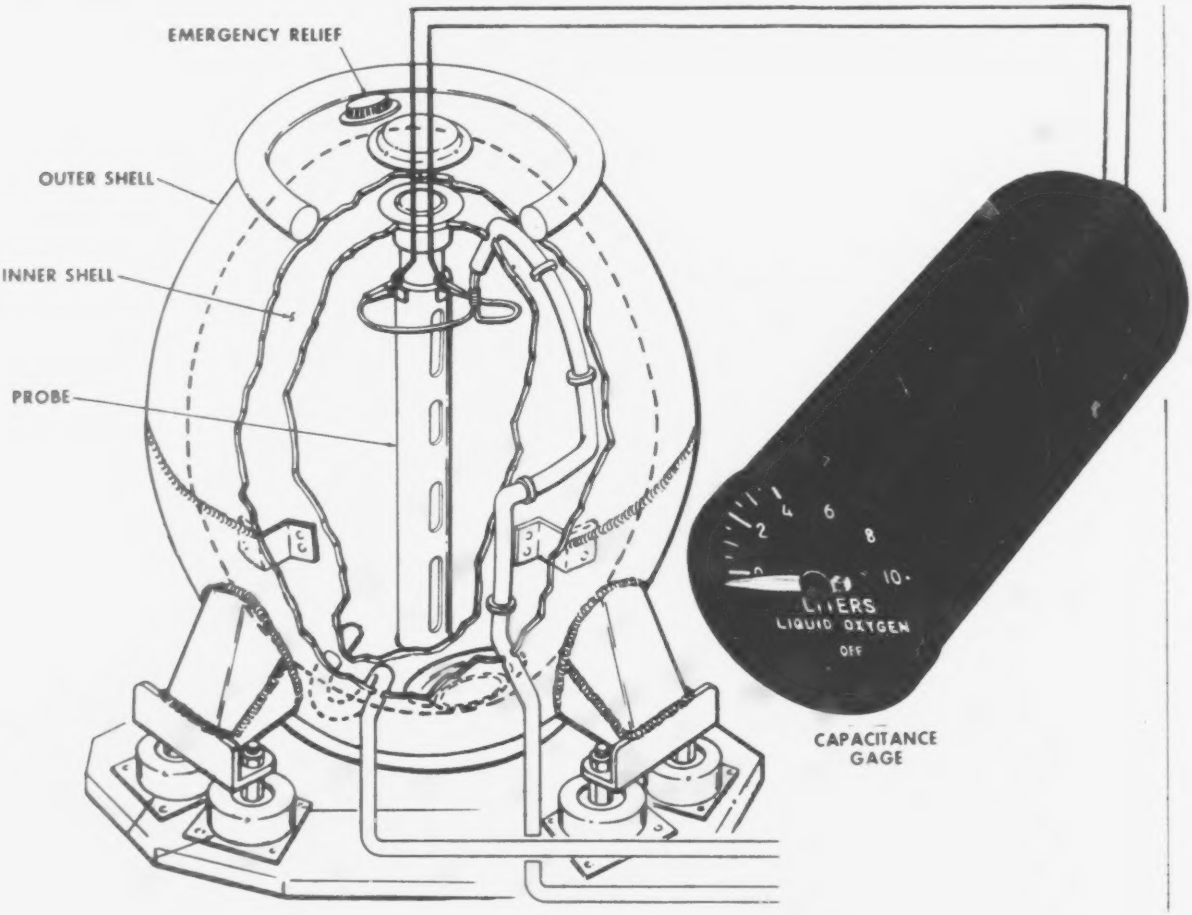
EMERGENCY RELIEF
OUTER SHELL
INNER SHELL
PROBE
0
2
4
6
8
10
LITERS
LIQUID OXYGEN
OFF
CAPACITANCE GAGE

Figure 2.

Check the following statement(s) that are true.

1. ____ The variable capacitance probe is located inside the liquid container.

2. ____ When the liquid level changes a signal is sent to the capacitance gage.

Answers to Frame 2: ✓ 1. ✓ 2. ____3.

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As you may recall, a capacitor has two conducting plates with an insulating material separating them. This insulating material is called the dielectric. Materials such as glass, air, mica, waxpaper, and oil are used as dielectrics. In this case we are using liquid oxygen as the dielectric between the two plates of the probe as shown (in figure 3). As the liquid level goes up and down, a varying capacitance signal is made. The signal is passed on to the capacitance gage by means of a shielded electrical lead and a coaxial cable.

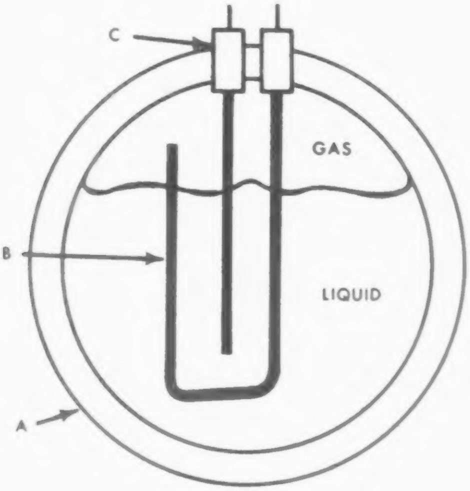


Figure 3.

Check the following statement(s) that are true.

1. ____ Oil is used as a dielectric in this system.

2. ____ The shielded electrical lead and coaxial cable transmit the signal to the gage.

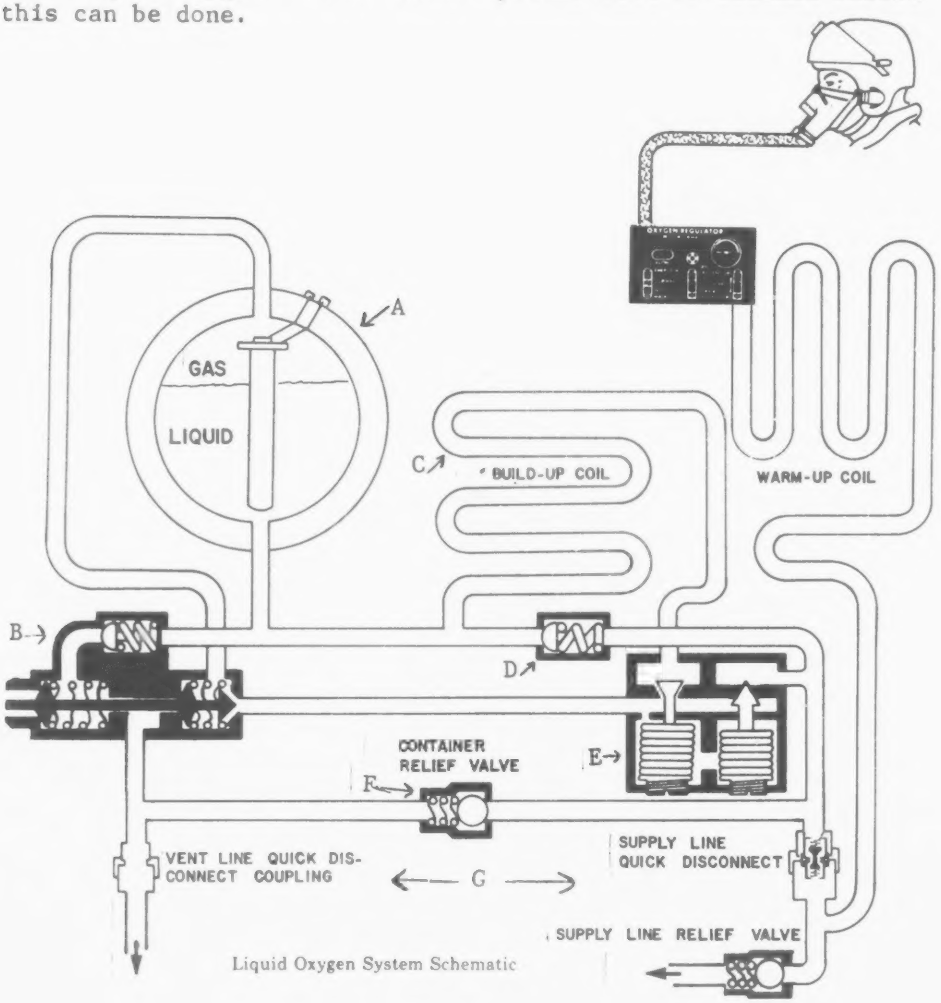
3. ____ Liquid oxygen is used as an insulating material.

Answers to Frame 3: ____1. ✓ 2.

Frame 6

Shown (in figure 4) is a complete liquid oxygen system. The converter portion of this system consists of the following parts: (A) Container, (B) Fill, Build-up and Vent Valve, (C) Build-up coil, (D) Liquid Check Valve, (E) Pressure Opening-Pressure Closing Valve, (F) Container Relief Valve, (G) Quick Disconnects; Supply Line and Vent Line.

> Note: These quick disconnects are a unique feature of this system and are not normally found on most liquid oxygen systems. They enable the converter to be removed and installed on the aircraft with liquid oxygen in it. Other systems must be drained before this can be done.


A
GAS
LIQUID
C
BUILD-UP COIL
WARM-UP COIL
OXYGEN REGULATOR
B
D
E
F
CONTAINER RELIEF VALVE
VENT LINE QUICK DIS-CONNECT COUPLING
G
SUPPLY LINE QUICK DISCONNECT
SUPPLY LINE RELIEF VALVE

Liquid Oxygen System Schematic

Figure 4.

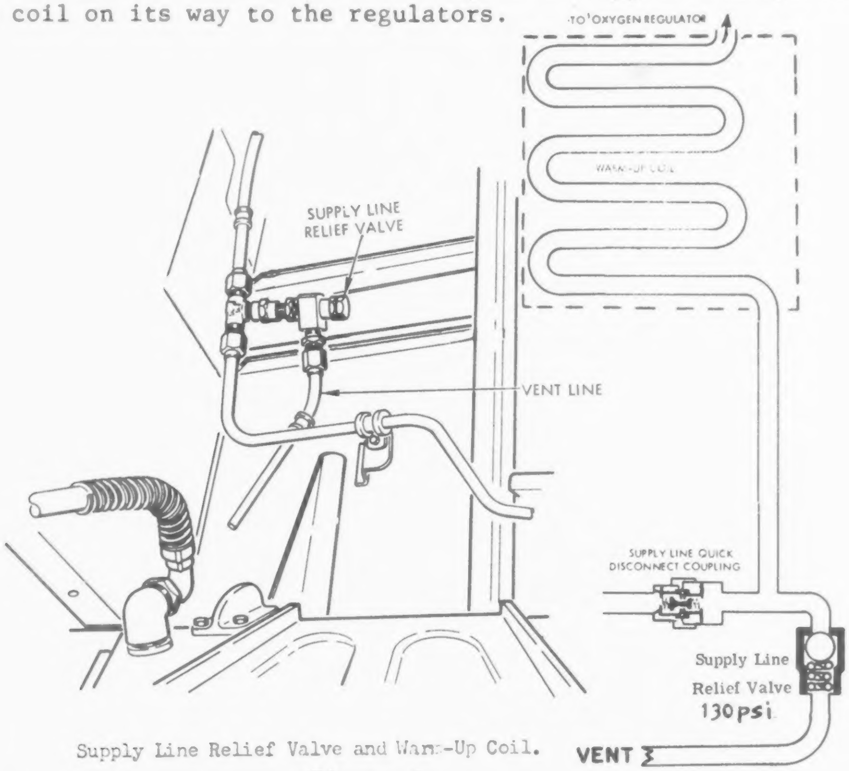
Check the following statement(s) that are true.

1. ____ The Liquid Check Valve is part of the converter assembly.
2. ____ The system (in figure 4) must be drained before the converter can be removed from the aircraft.
3. ____ Quick disconnects are found on most liquid oxygen systems.

Answers to Frame 4: ✓ 1. ✓ 2.

So far we have discussed the converter assembly and its components. Now let's look at the components of the oxygen system that are fixed to aircraft (see figure 5). The supply line relief valve is set at 130 psi and relieves excessive pressure in the supply line and warm-up coil (or warm-up plate). When the converter assembly is removed at the quick disconnects, oxygen is trapped in the supply line and warm-up coil and pressures may become excessive if the temperature changes. The supply line relief valve takes care of this. Also, if the container relief valve fails, the supply line relief valve will take over.

The purpose of the warm-up coil or plate is to raise the temperature of the gaseous oxygen to where it is suitable for breathing. The coil is usually in the cockpit or electronics compartment. Heat in the area surrounding the coil is transferred to the gaseous oxygen as it passes through the coil on its way to the regulators.


TO OXYGEN REGULATOR
WARM-UP COIL
SUPPLY LINE RELIEF VALVE
VENT LINE
SUPPLY LINE QUICK DISCONNECT COUPLING
Supply Line Relief Valve 130psi
VENT

Supply Line Relief Valve and Warm-Up Coil.

Figure 5.

Select the following statement(s) that is/are true.

1. ____ The supply line relief valve is fixed to the aircraft and set at 130 psi.
2. ____ As gaseous oxygen passes through the warm-up coil, its temperature rises.
3. ____ If the container relief valve fails, the supply relief valve takes over.

Answers to Frane 5: ____1. _✓_2. _✓_3.

Frame 8

The combination fill, build-up, and vent valve shown (figure 6) is a dual function valve. On older oxygen systems, it would be divided into two separate valves (1) the fill valve and (2) the build-up and vent valve. The fill portion of the combination valve has a coupling for the filler nozzle of a LOX servicing cart to connect to. As shown in (figure 6) the valve is normally in the build-up position. The build-up port is connected to the pressure opening-pressure closing valve. Gaseous oxygen flows from the pressure opening-pressure closing valve through the build-up port into the combination valve. It then flows out of the gas port, back to the top of the container. The fill out port on the valve is connected to the bottom of the container. The ball check valve in this port prevents a reverse flow of liquid (from the bottom of the container) through the valve. A dust cap attached to a chain is used on the filler port of this valve. This cap protects the seal on the filler port from damage and contamination.

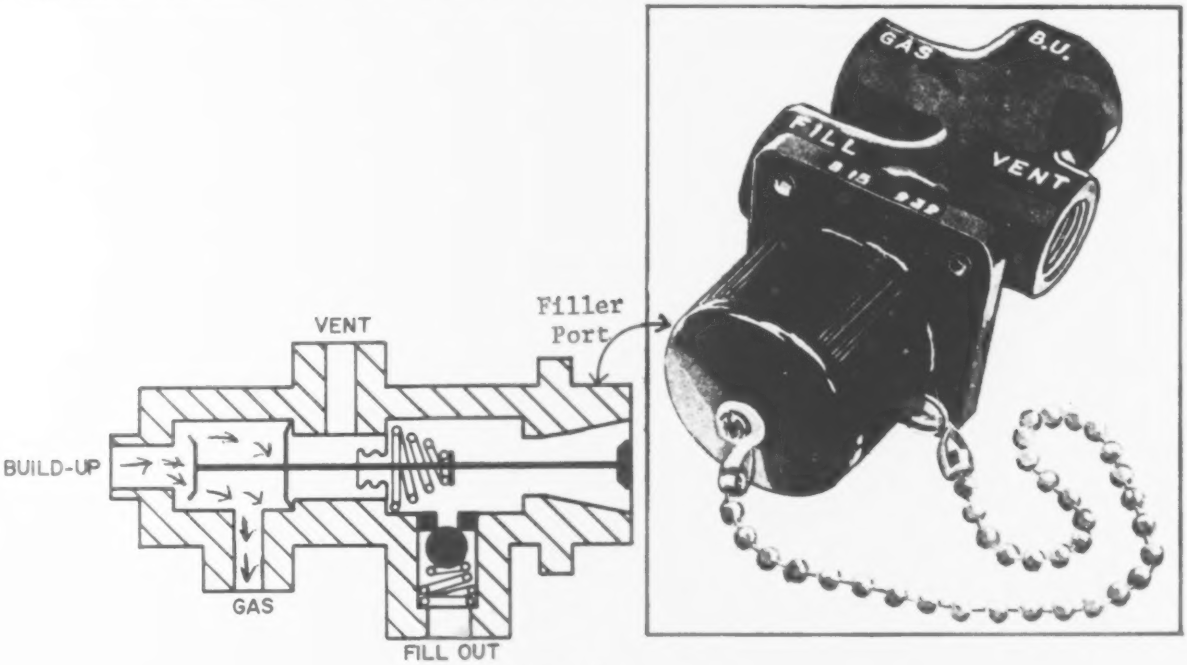


Figure 6.

Check the following statement(s) that are true.

1. ____ The combination valve is normally in the build-up position.

2. ____ Reverse flow of liquid is prevented by the ball check valve.

Answers to Frame 6: ✓ 1. ____2. ____3.

Frame 9

When the filler nozzle from the liquid oxygen servicing trailer is connected to the fill, build-up, and vent valve, it will be in the position shown below (figure 7). A pin in the filler nozzle pushes the valve shaft backwards and closes the build-up port. At the same time, the gas port is opened to the overboard vent and system pressure is discharged overboard. When the liquid flows in under pressure, it unseats the ball check valve in the "fill out" port and goes into the container. When the filler nozzle is removed, the ball check valve reseats, the valve shaft moves out and automatically returns the system to "build-up."

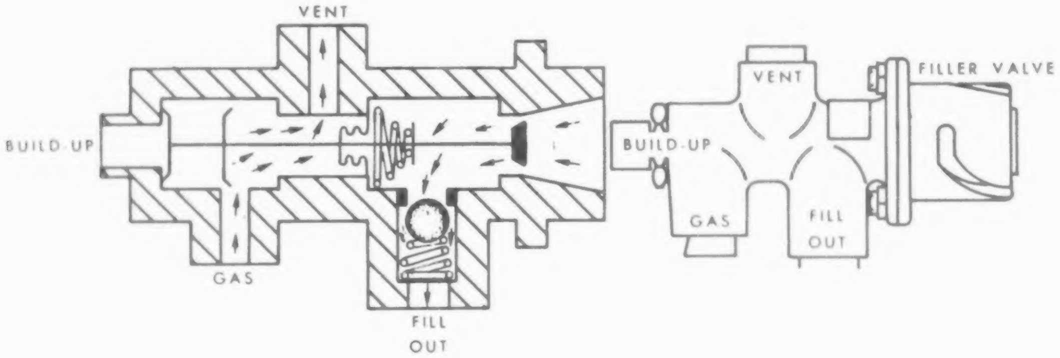


Figure 7.

Shown in Fill & Vent.
Combination Fill, Build-up, and Vent Valve.

Select the following statement(s) that is/are true.

1. ____ When the filler nozzle is connected, system pressure is vented overboard.

2. ____ The normal position of the fill, build-up, and vent valve is "vent."

3. ____ When the filler nozzle is removed, the valve returns to "build-up."

4. ____ When servicing the system, the incoming liquid unseats the ball check valve in the "fill out" port.

5. ____ When the filler nozzle is connected, the valve automatically moves from build-up to vent.

Answers to Frame 7: ✓ 1. ✓ 2. ✓ 3.

Frame 10

The pressure opening-pressure closing valve is a single component that contains two separate parts (see figure 8). The pressure closing valve acts as the pressure regulator for the liquid oxygen system. It will either be preset at 70 psi or 300 psi depending upon the type of system the aircraft requires. The main purpose of the high pressure (300 psi) is to allow crew members to fill walk around bottles from the aircraft system. This means that bomber and cargo aircraft will have to use high-pressure systems.

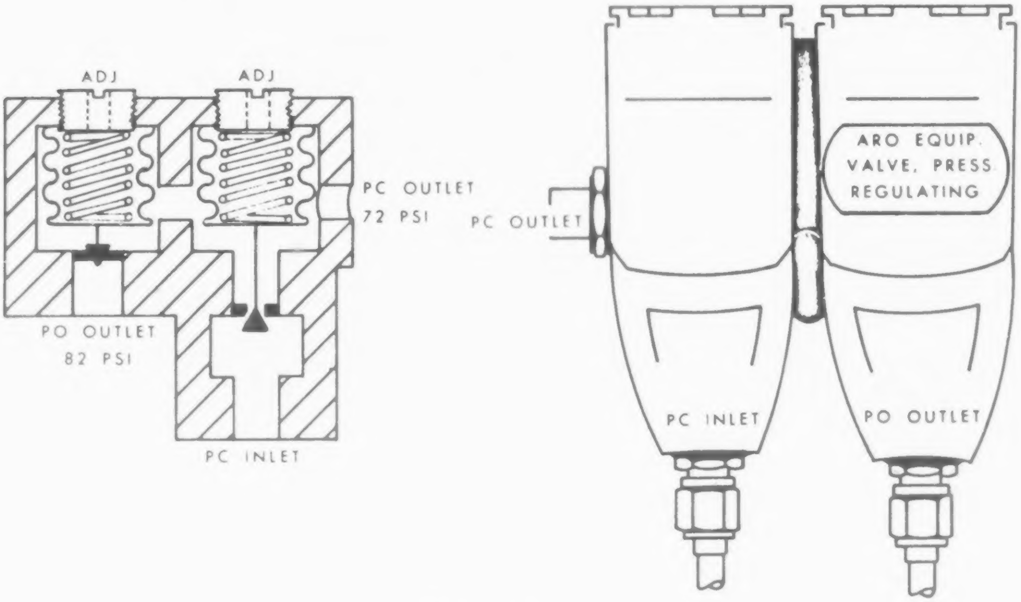

ADJ
ADJ
PC OUTLET
72 PSI
PO OUTLET
82 PSI
PC INLET
PC OUTLET
ARO EQUIP.
VALVE, PRESS
REGULATING
PC INLET
PO OUTLET

Figure 8.

Check the following statement(s) that are true.

1. ____ The pressure closing valve acts as a pressure regulator.

2. ____ Fighter aircraft would require a high-pressure liquid oxygen system.

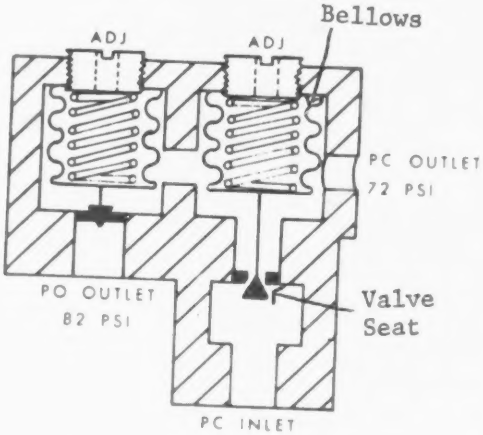
3. ____ The pressure closing valve is set at 70 or 300 psi.

4. ____ The main reason for having high-pressure liquid oxygen is to fill walk-around bottles.

5. ____ The low-pressure liquid oxygen system operates at 70 psi.

Answers to Frame 8: ✓ 1. ✓ 2.

Because the pressure closing valve is going to act as the pressure regulator for the system, its primary purpose is to maintain a constant head pressure on top of the liquid in the storage container. The head pressure (gas) is used to push the liquid out the bottom of the container and into the evaporator coil where it is converted to a gas. The bellows in the pressure closing valve (see figure 9) will sense the head pressure and open the valve if pressure drops below the valve setting (70 or 300 psi). When the valve opens, gaseous oxygen is transferred from the evaporation side of the system to the build-up side to maintain head pressure. The pressure closing valve is normally an open valve and is a part of the converter assembly.



Combination Pressure Opening -
Pressure Closing Valve

Figure 9.

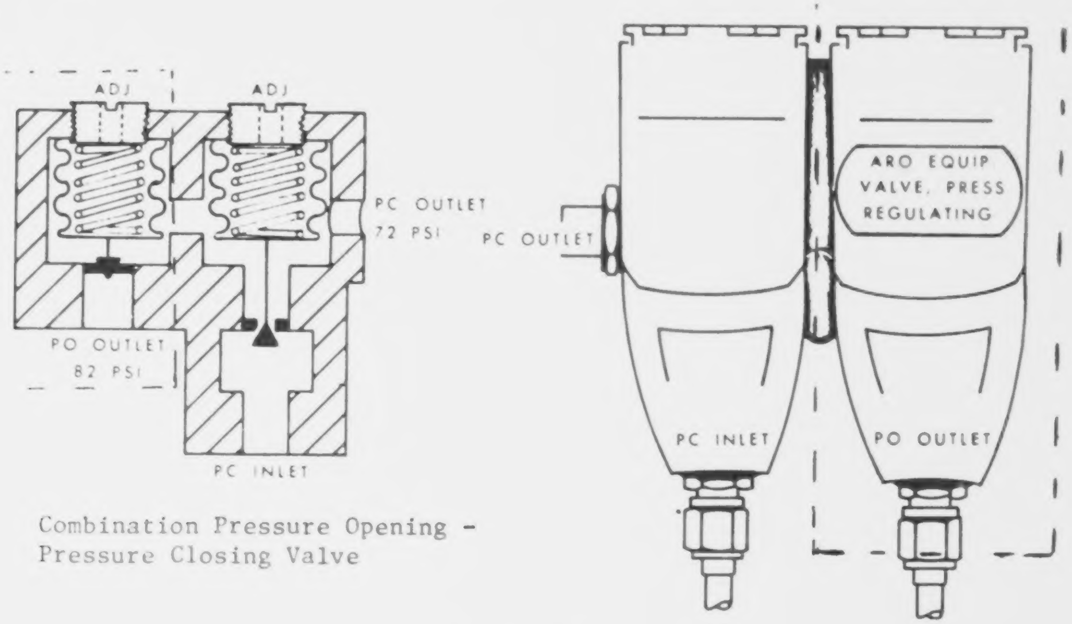
Check the following statement(s) that are true.

1. ____ The pressure closing valve maintains a constant head pressure.
2. ____ The pressure closing valve is part of the converter assembly.
3. ____ The pressure closing valve acts as the system pressure regulator.
4. ____ The head pressure (gas) pushes the liquid out of the container.
5. ____ The pressure closing valve transfers liquid oxygen in the system.

Answers to Frame 9: _✓_ 1. ____ 2. _✓_ 3. _✓_ 4. _✓_ 5.

Frame 12

The pressure opening valve (PO) is the second portion of the pressure-opening-pressure-closing valve. Both valves (shown in figure 10) are bellows operated pressure regulating valves contained in one housing. As you already know the pressure-closing (PC) valve is a normally open valve that regulates system pressure to 70 psi by controlling the container "head pressure".



Combination Pressure Opening -
Pressure Closing Valve

Figure 10.

The presure-opening valve is normally closed. It will open when pressure in the system reaches 82 psi or above. The pressure opening valve's function is to conserve gaseous oxygen. When the pressure-opening valve opens gaseous oxygen is drawn directly from the top of the container by the breathing of the crew. This excess head pressure is used for crew breathing until system pressure drops below 82 psi. The pressure opening valve then closes and the system returns to normal.

> Note: Some systems do not have a combination pressure opening-pressure closing valve. These systems have a single pressure-closing valve. The pressure-closing valve in these systems, regulates pressure up to 82 psi. When the pressure in the system reaches 82 psi (or above) the excess pressure is vented overboard by a relief valve.

Check the following statement(s) that are true.

1. ____ The pressure-opening and pressure-closing valves are contained in the same housing.

2. ____ The pressure-opening valve allows gaseous oxygen to be drawn from the top of the container at 82 psi.

Answers to Frame 10: ✓ 1. ____2. ✓ 3. ✓ 4. ✓ 5.

Frame 13

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The liquid check valve is especially made to work in a liquid oxygen system. From its place in the system, it will do two things: (1) It separates the liquid phase of operation from the gaseous phase. (2) It stops a reverse flow of gaseous oxygen (from the gaseous phase) back through the liquid container. During normal operation of the system, the liquid check valve allows liquid to be drawn from the bottom of the container into the evaporation coils in the direction of the arrow. As pressure in the build-up and evaporation sides changes because of use or liquid boil-off, the check valve will open and close at 5 psi below the container head pressure. This makes a 5 psi differential between the gaseous phase and liquid phase. When we discuss overall system operation, the function of the valve will become more clear.

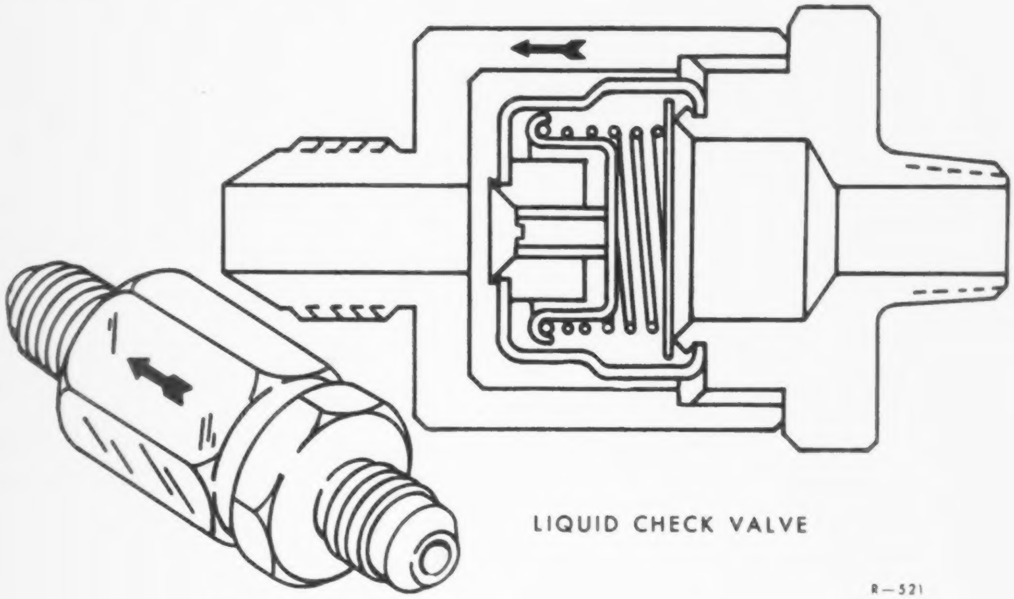

Figure 11.

Check the following statements that are true.

1. ____ The check valve separates the liquid and gaseous phase of system operation.

2. ____ The liquid check valve is especially designed for liquid oxygen systems.

3. ____ The check valve opens or closes at 5 psi below container head pressure.

4. ____ When the check valve closes, it prevents reverse flow.

Answers to Frame 11: ✓ 1. ✓ 2. ✓ 3. ✓ 4. ____ 5.

Frame 14

Now that you are familiar with the dual function valves used in this type of system, let's discuss the operation of this system (see figure 12). In order to fully understand what is taking place within the system, it is necessary to look at the system in four (4) different phases of operation. The first phase is FILLING and this is shown below. When the nozzle from the servicing trailer is connected to the fill, build-up and vent valve, the plunger in the valve is pushed in as shown. This closes the build-up line and provides an open line to the overboard vent. Any pressure in the system is now vented overboard. When the liquid oxygen enters the valve, it unseats the fill check valve and goes into the container through the bottom. When the container is full, liquid flows out the top of the container, back through the valve and out the overboard vent. At this time, the nozzle from the servicing trailer is removed and this automatically places the system in the build-up phase.

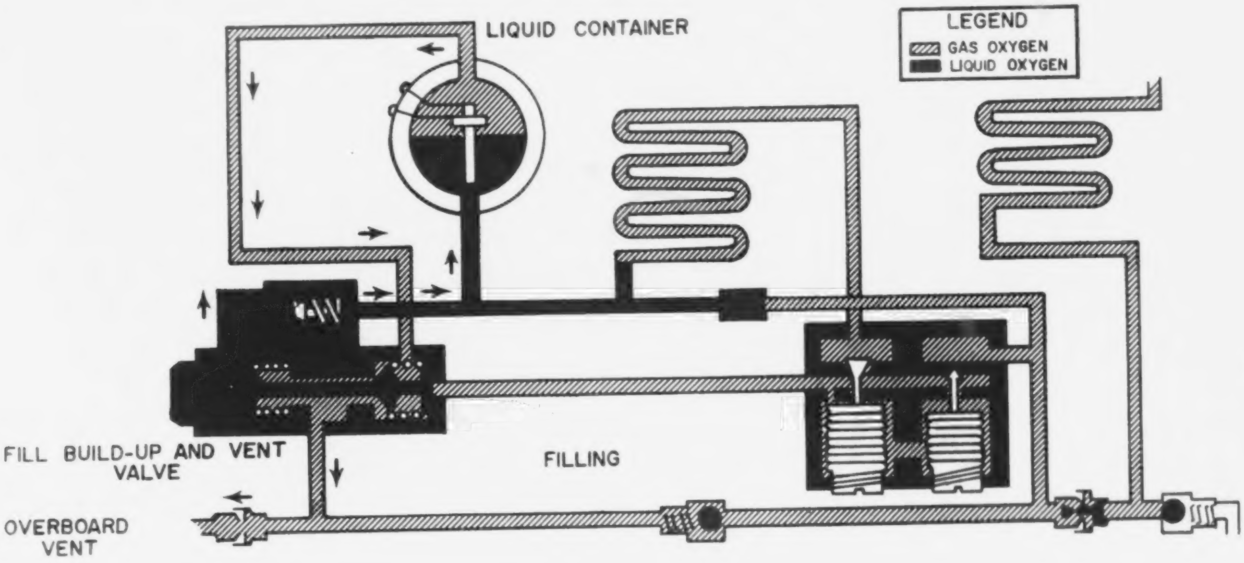

Figure 12.

Select the following statement(s) that is/are true.

1. ____ The fill check valve is unseated when filling the system.

2. ____ The liquid check valve is closed when filling.

3. ____ When filling, the pressure closing valve is open (normal position).

4. ____ When filling, liquid oxygen enters the warm up coil.

5. ____ System pressure is vented overboard when the filling nozzle is connected.

Answers to Frame 12: ✓ 1. ✓ 2.

Frame 15

Once the transfer hose nozzle is removed, pressure begins to build up in the system. This pressure build-up continues until system pressure reaches 72 psi. Figure 13 illustrates this pressure build-up phase. Note that liquid is boiling off in the build-up coil and returning to the top of the container through the pressure closing valve (which is open) and the fill, build-up and vent valve. The container is building up "head" pressure. During this phase, breathing oxygen is obtained from liquid oxygen drawn through the liquid check valve (shown open). This liquid will vaporize as it passes through the supply line and warm up coil on its way to the oxygen regulator.

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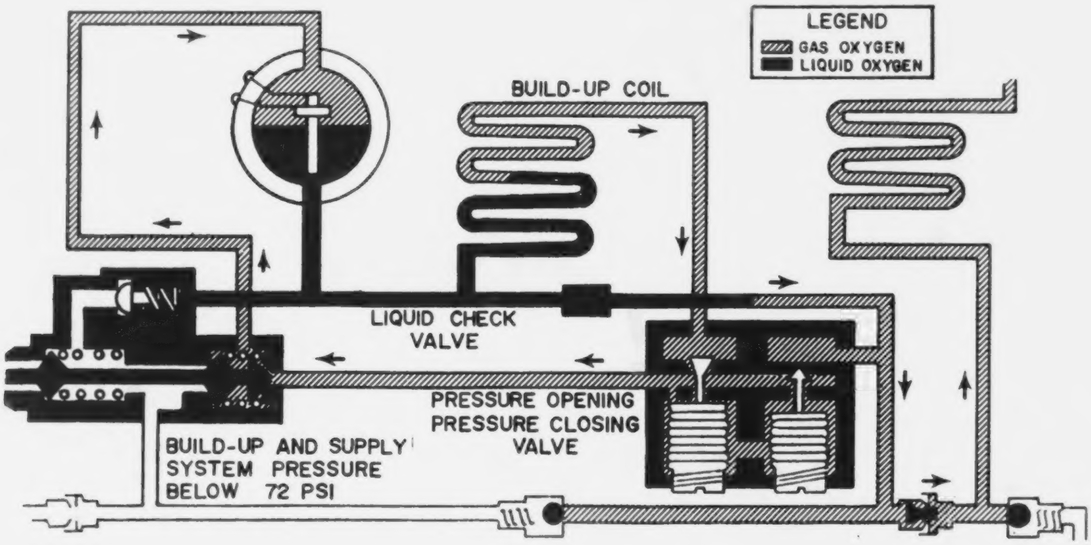

LEGEND
▨ GAS OXYGEN
■ LIQUID OXYGEN
BUILD-UP COIL
LIQUID CHECK VALVE
PRESSURE OPENING
PRESSURE CLOSING VALVE
BUILD-UP AND SUPPLY SYSTEM PRESSURE BELOW 72 PSI

Figure 13.

Select the following statement(s) that is/are true.

1. _____ When system pressure is below 72 psi the pressure closing valve is closed.

2. _____ When the transfer hose nozzle is removed, the system returns to build-up.

3. _____ During the build-up phase, the build-up coil is supplying gaseous oxygen which is returned to the top of the container.

4. _____ During this phase, liquid oxygen is drawn through the liquid check valve and vaporized in the supply line and warm up coil.

5. _____ During this phase, the container relief valve is open.

Answers to Frame 13: ✓ 1. ✓ 2. ____ 3. ✓ 4.

Frame 16

In this phase of operation (shown in figure 14) breathing oxygen is obtained from gaseous oxygen drawn through the liquid check valve. In this condition the pressure-closing valve is closed (closed at 72 psi) and the pressure-opening valve is still closed (opens at 82 psi). With the pressure closing valve closed, pressure build-up in the system is stopped because the return path to the top of the container is blocked. The liquid trapped in the build-up coil now evaporates (shown evaporated) and causes a back flow of liquid to the container. This action is what enables gaseous oxygen to be drawn through the liquid check valve (see schematic). As the pressure is lowered by the oxygen being used, the pressure closing valve will open and pressure will again build-up.

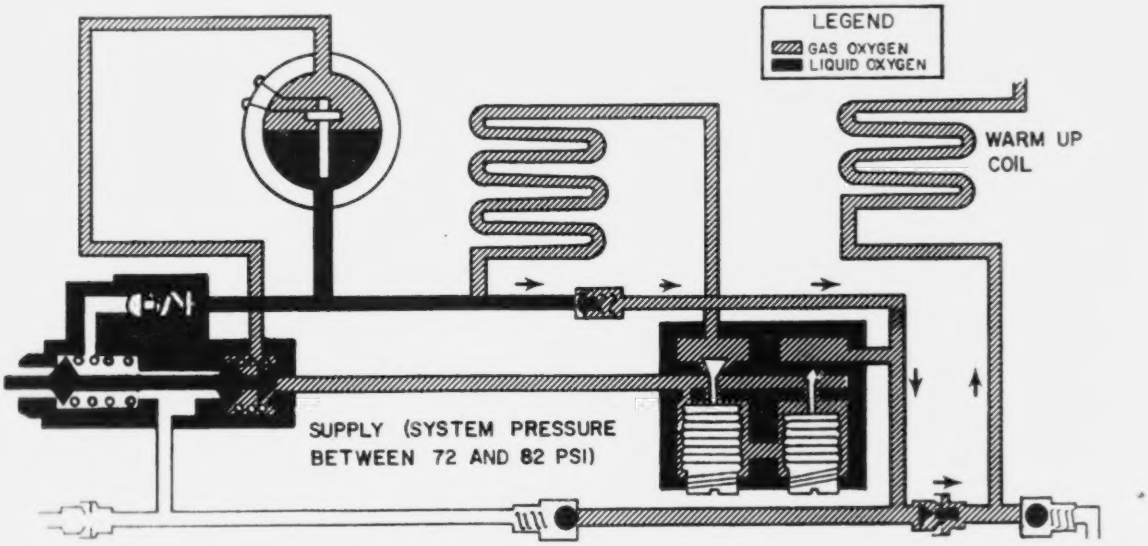


Figure 14.

Select the following statement(s) that is/are true.

1. ____ When system pressure is between 72 and 82 psi, the pressure closing and pressure opening valves are closed.

2. ____ When the pressure closing valve closes, pressure build-up is halted.

3. ____ The pressure closing valve is set to close at 52 psi.

4. ____ When the pressure closing valve closes, liquid oxygen trapped in the build-up coil will evaporate and cause a back flow.

5. ____ In this phase, gaseous oxygen for breathing is drawn through the liquid check valve.

Answers to Frame 14: ✓ 1. ✓ 2. ✓ 3. ____4. ✓ 5.

In cases where the use of gaseous oxygen is below normal as shown in (figure 15) at the regulator (low demand), and repeated cycling of the system causes excessive pressure build-up, the pressure opening valve will open. The pressure opening valve will open at 82 psi as shown below. When this valve opens, gaseous oxygen for breathing is drawn from the top of the container through this valve and out to the warm up coil. The pressure opening valve remains open as long as normal evaporation in the container is adequate to maintain system pressure above 82 psi. With this valve open, a back pressure will close the liquid check valve as shown. This phase of operation continues until system pressure drops below 82 psi again. When the oxygen system is not being used at all, normal evaporation in the container will cause pressure to build up until it reaches the setting of the container relief valve (110 psi). This will vent excess pressure overboard.

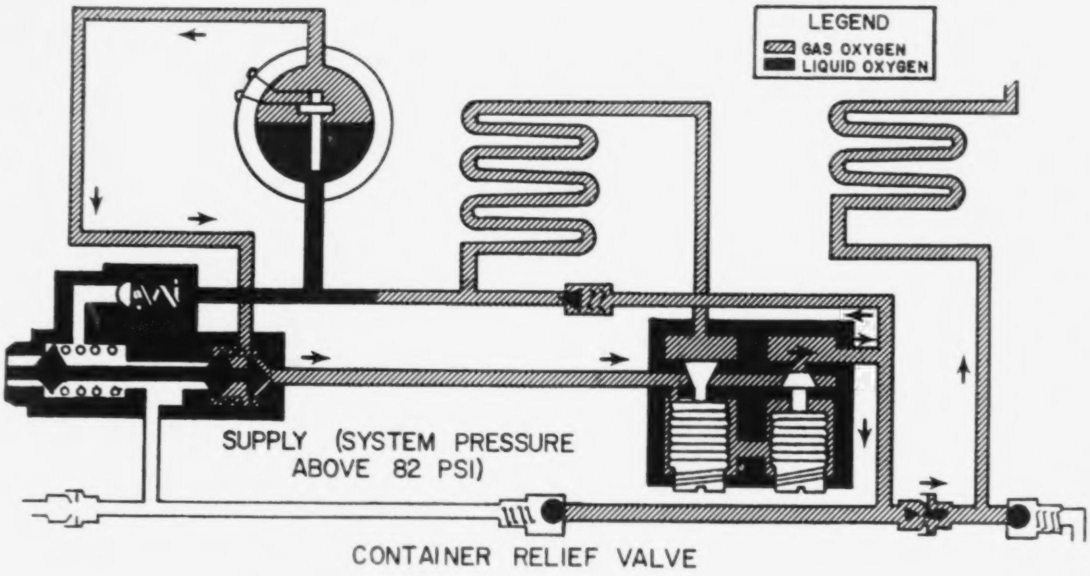


Figure 15.

Select the following statement(s) that is/are true.

1. ____ The pressure opening valve opens at 82 psi.

2. ____ A low demand on the system causes pressure to build up.

3. ____ When the pressure opening valve is open, breathing oxygen is drawn from the top of the container.

4. ____ In this phase, the liquid check valve is open.

5. ____ If no oxygen is being used, pressure will rise to the relief valve setting.

Answers to Frame 15: ✓ 1. ✓ 2. ✓ 3.

Frame 18

Instructions

The following page has a schematic (figure 16) of the liquid oxygen system we have been discussing. Use this page to do the following:

Part 1

Identify the components in the system by placing the letters from the arrowed circles by the correct name of that component in the given list. Check your answers on the following page.

Part 2

Draw the necessary valves open or closed (with a black pencil) to indicate the position they would take if the system pressure was above 82 psi. Now use a red pencil and trace in the liquid flow and a blue pencil to show gaseous oxygen flow. Check your tracing against the schematic for this phase of operation in the text.

Answers to Frame 16: ✓ 1. ✓ 2. ___ 3. ✓ 4. ✓ 5.

1.____Vent Quick Disconnect.

2.____Fill,Build-Up,and Vent Valve.

3.____Fill Check Valve.

4.____Liquid Container.

5.____Build-Up Coil.

6.____Liquid Check Valve.

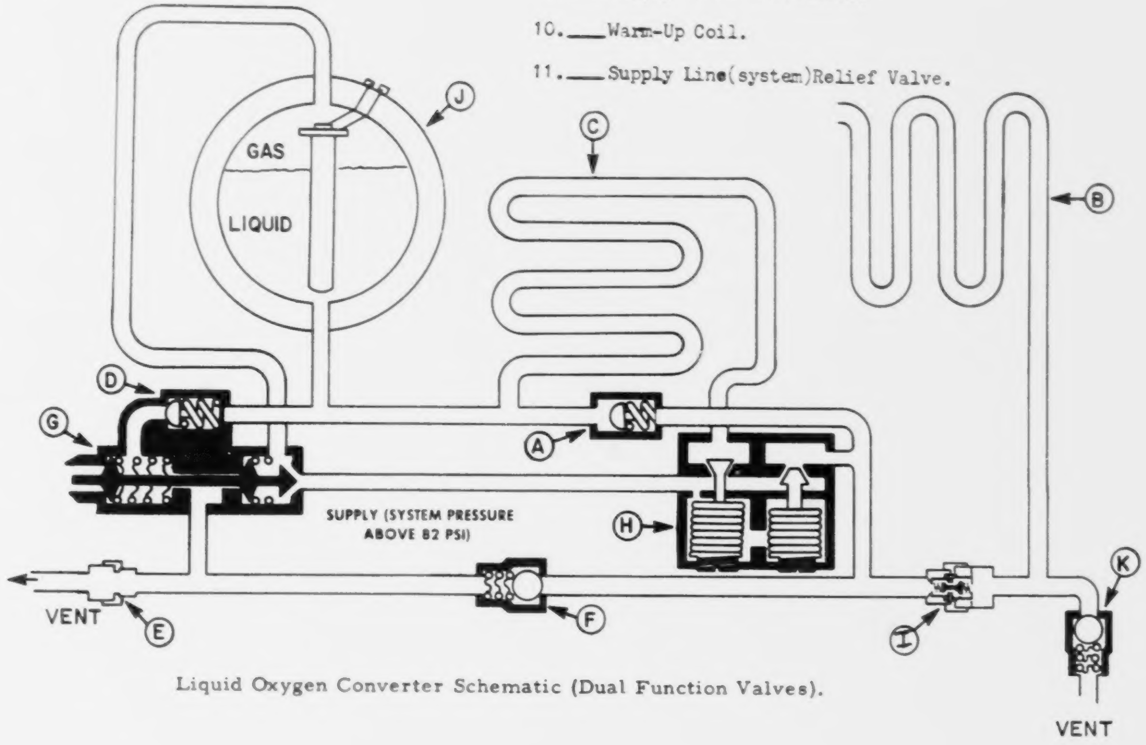
7.____Pressure Opening-Pressure Closing Valve.

8.____Container Relief Valve.

9.____Supply Quick Disconnect.

10.____Warm-Up Coil.

11.____Supply Line(system)Relief Valve.


J
GAS
LIQUID
C
B
D
G
A
SUPPLY (SYSTEM PRESSURE
ABOVE 82 PSI)
H
K
VENT
E
F
I
VENT

Liquid Oxygen Converter Schematic (Dual Function Valves).

Frame 19

We have told how the LOX is stored and turned into gaseous oxygen. Now we will talk about the different ways this oxygen can be delivered to the crew by the regulators. Oxygen systems are usually referred to by the type of regulator installed in the distribution section of the system. If a system has a continuous flow regulator installed, it would be referred to as a continuous flow system, etc. There are three types of oxygen systems that we will discuss, the Demand, Pressure Demand, and Continuous Flow type systems.

Check the following statement(s) that are true.

1. ____ A pressure demand system uses a pressure demand regulator.

2. ____ Demand, Pressure Demand and Continuous flow are three different ways oxygen can be delivered to the crew.

Answers to Frame 17: _✓_ 1. _✓_ 2. _✓_ 3. ____ 4. _✓_ 5.

Frame 20

The demand oxygen systems main component is the diluter demand regulator. The regulator gets its name from the fact that it delivers oxygen mixed with air, to your lungs, in response to the suction of your breath; that is, on demand. It will supply enough oxygen for all altitudes up to 35,000 feet. Each time you inhale, you close a valve in the mask and open a valve in the regulator. When you exhale, you reverse this process.

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Below 34,000 feet the diluter feature of this regulator mixes suitable amounts of cabin air with 100% oxygen from the converter. This will conserve the oxygen from the converter. At altitudes above 34,000 feet, an aneroid (bellows assembly) will contract, closing the air inlet of the regulator, allowing only oxygen to be supplied to the mask. This is 100% oxygen from the converter. To get 100% oxygen below 34,000 feet, a diluter control on the regulator can be moved from the normal oxygen position to the 100% oxygen position.

> Note: This is normally done only to test and check the oxygen system, in an emergency, or under special circumstances such as, the treatment of wounded or shock victims. High altitude missions also call for 100% oxygen.

Check the true statement(s).

1. ____ The main component of the demand system is the diluter demand regulator.
2. ____ The demand system responds to the suction of your breath.
3. ____ The diluter demand regulator mixes air and oxygen at 35,000 feet.
4. ____ 100% oxygen can be obtained from the diluter demand system below 34,000 feet.

Answers to Frame 18: _E_ 1. _G_ 2. _D_ 3. _J_ 4. _C_ 5. _A_ 6.

_H_ 7. _F_ 8. _I_ 9. _B_ 10. _K_ 11.

Frame 21

The diluter demand regulator sends oxygen, or oxygen mixed with air, to the user on demand or when he breathes. This is all just fine until we reach a height of about 40,000 feet. From 40,000 feet up, the human body needs oxygen under pressure to work the way it should. At sea level pressure, carbon dioxide and water are stable in the blood stream and oxygen saturation of the blood is 100%. At low atmospheric pressure (high altitude), carbon dioxide and water vaporize in the lungs and pressure builds up that keeps oxygen from entering the lungs. By adding pressure to the oxygen (pressure breathing), we get rid of this pressure in the lungs and force the carbon dioxide out and force oxygen in. Look at figure 17 to see why different systems are required.

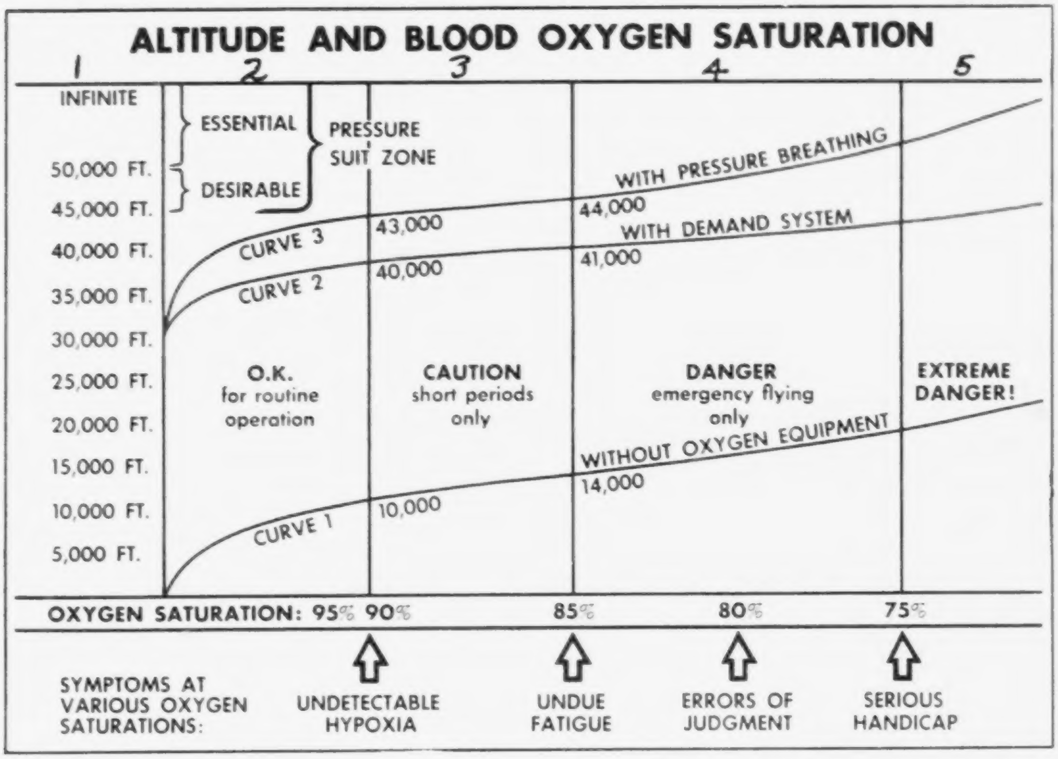

Figure 17.

Check the following statement(s) that are true.

1. ____ 40,000 feet is the limit of a demand oxygen regulator.

2. ____ 10,000 feet is the highest a person can reach safely without oxygen equipment.

3. ____ At 45,000 feet a pressure suit should be worn.

4. ____ 44,000 feet is the highest a pilot can safely fly with a pressure breathing system.

Answers to Frame 19: ✓ 1. ✓ 2.

With pressure breathing, as shown in the chart in the past frame, we are safe up to a height of about 50,000 feet. Above this height, the carbon dioxide and water vapor pressure will rise to a point where any more of an increase in oxygen pressure would damage the lungs. Also, above 50,000 feet, a pressure suit is needed in case cabin pressure is lost. Without any pressure blood will boil at 60,000 feet, so you can see the need of this equipment.

Now that you know why we need pressure breathing, let's talk about the pressure demand oxygen regulator. Below 35,000 feet the pressure demand oxygen regulator, functions as an ordinary demand regulator. Above 35,000 feet, the regulator has a positive pressure mechanism which comes into operation, either by manually positioning a dial on the regulator, or automatically by an aneroid in the regulator. This positive pressure mechanism will deliver oxygen to your lungs at a pressure slightly higher than that outside your body.

Check the following statement(s) that are true.

1. ____ Below 35,000 feet a pressure demand regulator functions as a demand regulator.

2. ____ Pressure breathing is automatically delivered above 35,000 feet by the pressure demand oxygen regulator.

Answers to Frame 20: _✓_ 1. _✓_ 2. ____ 3. _✓_ 4.

Frame 23

Continuous flow or constant flow oxygen equipment is not used in any of the combat type aircraft. It is used in some of the training aircraft, and all cargo aircraft that take part in air evacuation and the transporting of troops and cargo. The crew, which is in the front part of the aircraft, uses the demand type oxygen regulator, while the cargo part in the rear of the aircraft uses the constant flow system. The main reason for this is that the constant flow system does not meet the needs of the crew. The supply for the constant flow system is the same as it is for the demand system, either the gaseous or the liquid may be used. There are two types of continuous flow regulators, the hand adjustment types and the automatic types.

Check the following statement(s) that are true.

1. ____ Constant flow systems are not used in combat aircraft.

2. ____ Constant flow systems use only a gaseous oxygen supply.

Answers to Frame 21: _✓_ 1. _✓_ 2. _✓_ 3. _✓_ 4.

Frame 24

The hand adjustment type regulators are designed to deliver a continuous stream of oxygen, at a rate of flow, which is manually controlled. The pressure reducing mechanism and a needle valve control flow from the regulator. A pressure gage and flow indicator, calibrated in terms of altitude, are used to monitor flow from the regulator. Flow from the regulator is adjusted by turning the manual control knob until the reading of the flow indicator corresponds to the aircraft's altitude. If the aircraft is climbing at a rapid rate the flow indicator should be set about 5,000 feet above aircraft altitude.

Automatic type continuous flow regulators are used in transport aircraft for supplying oxygen to passengers, troops or litter patients. The regulator supplies oxygen automatically, and is controlled by an aneroid for increasing oxygen flow with increasing altitude. It has no manual controls or flow indicators. The main disadvantage of a continuous flow system is it uses oxygen at a very rapid rate. One regulator can supply up to 100 passengers with oxygen. To insure the oxygen supply is not depleted, a crewmember must monitor pressure at frequent intervals, on a pressure gage installed in the distribution line. Only one pressure gage is installed in each passenger compartment.

Check the following statement(s) that are true.

1. ____ The flow indicator is used to monitor flow from the regulator.
2. ____ The manual control knob controls flow from the regulator.
3. ____ Automatic continuous flow regulators are controlled by an aneroid.
4. ____ Continuous flow systems rapidly deplete oxygen.

Answers to Frame 22: ✓ 1. ✓ 2.
Answers to Frame 23: ✓ 1. ____ 2.
Answers to Frame 24: ✓ 1. ✓ 2. ✓ 3. ✓ 4.

SERVICE TEST
STUDY GUIDE

C3ABR42331-SG-402

Technical Training

Aircraft Environmental Systems Mechanic

LIQUID OXYGEN SYSTEMS

2 May 1984

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SERVICE TEST
C3ABR42331-SG-402

LIQUID OXYGEN SYSTEMS

OBJECTIVES

This study guide was designed to be used as study material for the measurement test. Information contained in this study guide can also be used for the progress check for this particular objective. There is also supporting material for the instructor's lesson.

INTRODUCTION

The liquid oxygen (LOX) system, which will be discussed in this text, is the source of gaseous oxygen for the crew.

While the low pressure and high pressure gaseous systems are still being used on Air Force aircraft, these systems are gradually being changed to the liquid oxygen system. Since inflight refueling was introduced, an aircraft can fly for long periods of time. The pilot and crew need large amounts of oxygen. The low pressure gaseous cylinders are light but take up a lot of space. The high pressure cylinders take up less space but are heavier. The best choice was to use the LOX system, which saves space and weight. The average weight and space reduction for all aircraft is 74%.

There are quite a few types of liquid oxygen systems used on Air Force aircraft. The type of system installed in an aircraft will depend upon the aircraft's manufacturer, and its mission. Liquid oxygen converters (containers) used on fighter type aircraft are small, (5 to 10 liter) low pressure 70 psi converters. Because of the size of the crew and the number of passengers, large bomber and cargo aircraft use the larger, (25 to 75 liter), high pressure, 300 psi converters.

CHARACTERISTICS OF LOX

LOX (liquid oxygen) is a pale blue, waterlike fluid; its boiling temperature is minus -297°F. This means that at any temperature above -297°F, for instance at -296°F, LOX will boil; changing state from liquid to gas. When liquid oxygen evaporates, it expands to about 860 times its original volume.

When working with LOX you should observe all safety precautions. Never allow LOX to come in contact with your skin. LOX, as we stated earlier, is extremely cold and can cause immediate frostbite (burns). If your skin does come in contact with LOX, you should flush the area with water and see a doctor immediately. Never confine LOX in any

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are light but take up a lot of space. The high pressure cylinders take up less space but are heavier. The best choice was to use the LOX system, which saves space and weight. The average weight and space reduction for all aircraft is 74%.

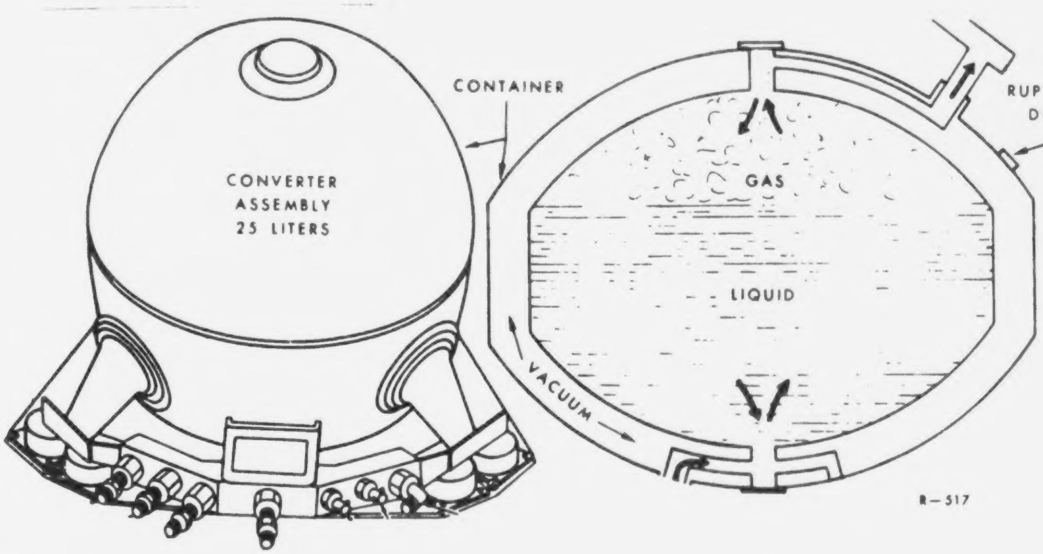


Figure 1.

CONVERTER

The liquid oxygen converter assembly (see figure 1) is the main part of a liquid oxygen system. This multi-function unit is designed to receive and store the liquid. It will also allow some liquid to change to a gaseous state. This gaseous oxygen is automatically supplied at a constant pressure to the oxygen regulator for crew use.

The container is the largest part of the converter assembly. The container is a double walled, vacuumed insulated unit similar to the common "Thermos" bottle. It is also known as a "Dewar" flask after its inventor. As shown (in figure 1) the liquid is stored in the inner shell and a vacuum separates it from the outer shell. The outer shell has a rupture disc installed that will blow out to prevent an explosion; if the inner shell develops a leak, the rupture disc will blow and relieve pressure at 30 psi.

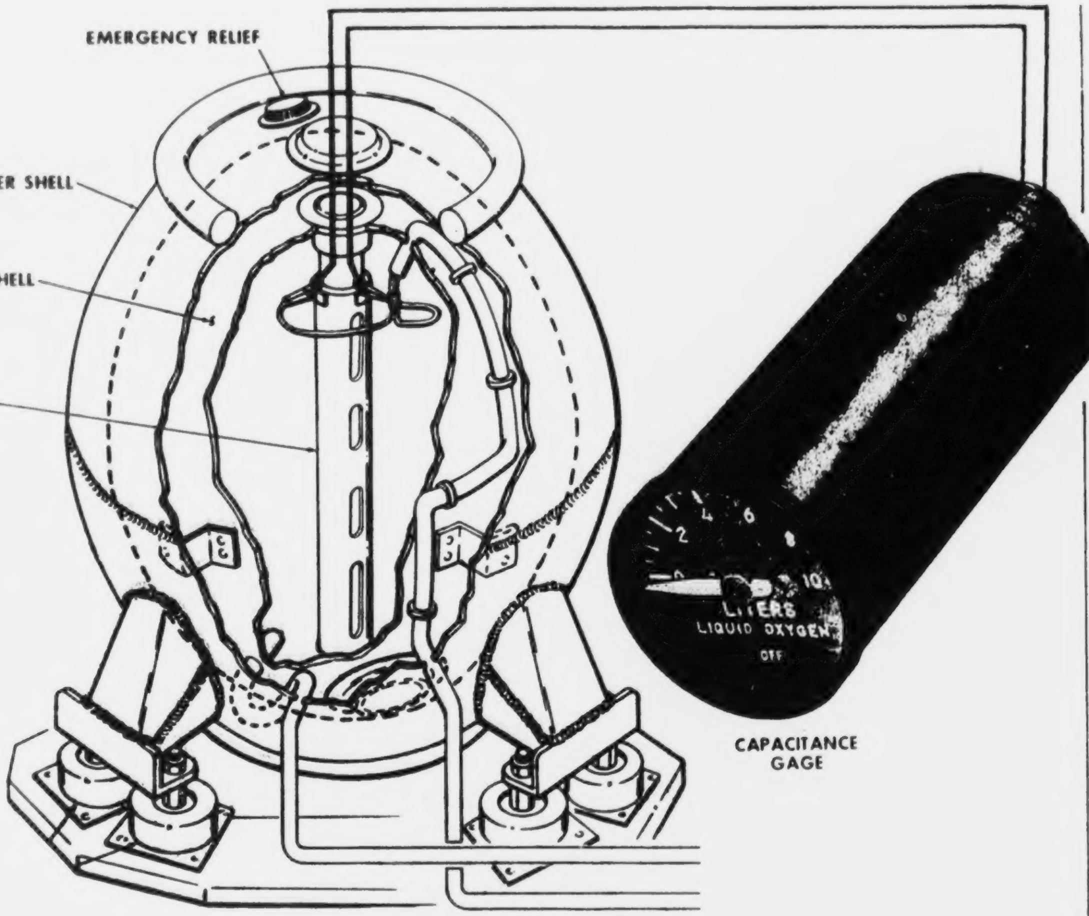

EMERGENCY RELIEF
OUTER SHELL
INNER SHELL
PROBE
0
2
4
6
8
10
LITERS
LIQUID OXYGEN
OFF
CAPACITANCE GAGE

Figure 2.

QUANTITY INDICATING SYSTEM

The quantity indicating system is a capacitance contents gage system. This indicating system uses a variable capacitance probe which is located in the liquid container (see figure 2). The probe varies capacitance as the liquid level changes. This varying signal is measured and turned into a liquid level indication by the capacitance gage.

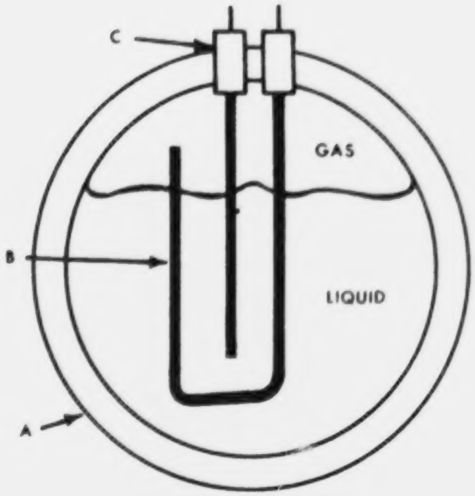
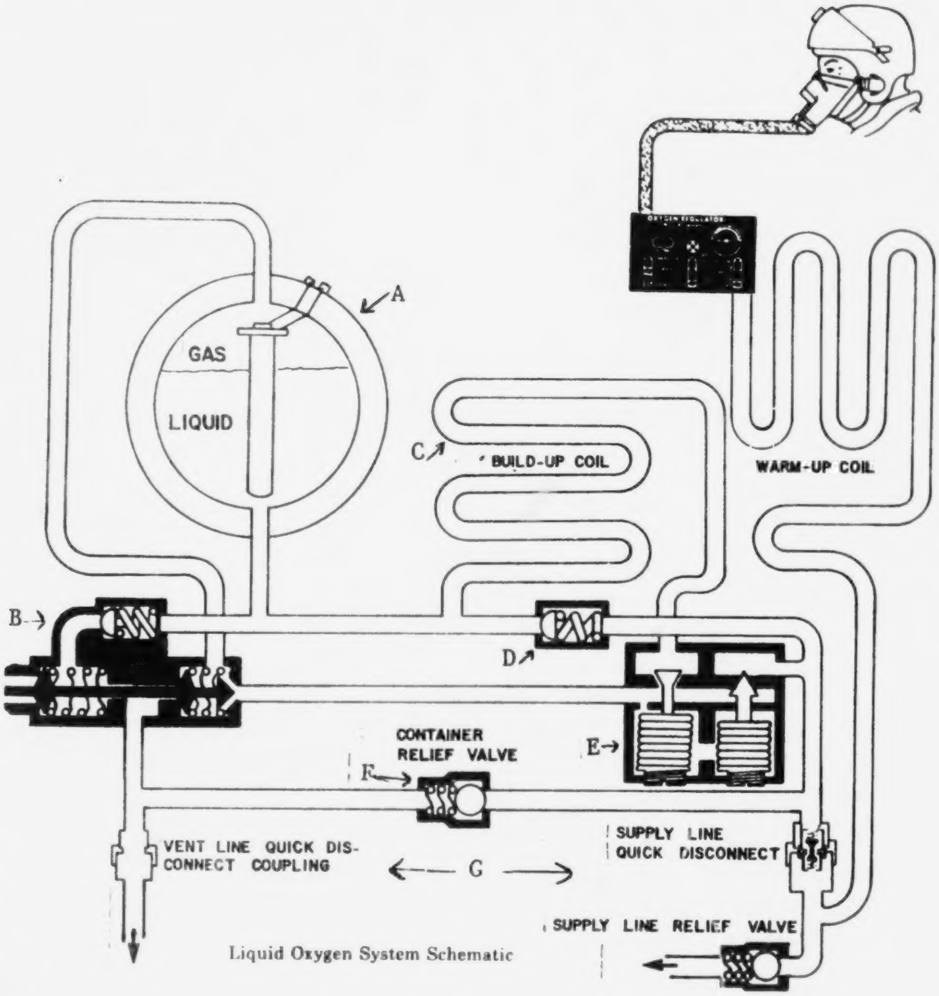


Figure 3.

As you may recall, a capacitor has two conducting plates with an insulating material separating them. This insulating material is called the dielectric. Materials such as glass, air, mica, waxpaper, and oil are used as dielectrics. In this case we are using liquid oxygen as the dielectric between the two plates of the probe as shown (in figure 3). As the liquid level goes up and down, a varying capacitance signal is made. The signal is passed on to the capacitance gage by means of a shielded electrical lead and a coaxial cable.


A
GAS
LIQUID
C
BUILD-UP COIL
WARM-UP COIL
B
D
E
CONTAINER RELIEF VALVE
F
VENT LINE QUICK DISCONNECT COUPLING
G
SUPPLY LINE QUICK DISCONNECT
SUPPLY LINE RELIEF VALVE

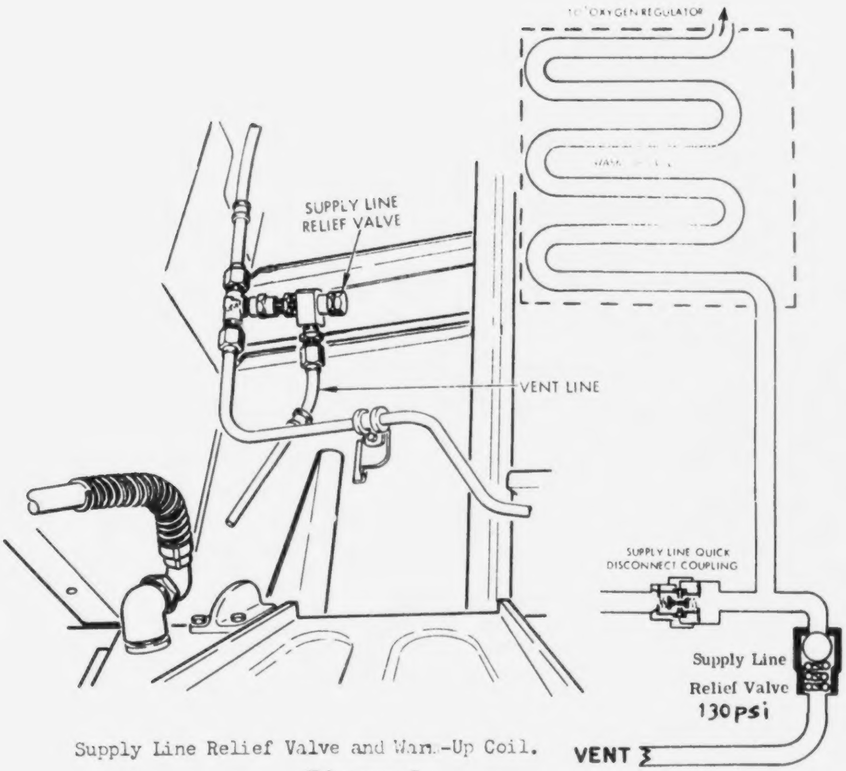
Liquid Oxygen System Schematic

Figure 4.

LIQUID OXYGEN SYSTEM

Shown (in figure 4) is a complete liquid oxygen system. The converter portion of this system consists of the following parts: (A) Container, (B) Fill, Build-up and Vent Valve, (C) Build-up coil, (D) Liquid Check Valve, (E) Pressure Opening-Pressure Closing Valve, (F) Container Relief Valve, (G) Quick Disconnects; Supply Line and Vent Line.

Note: These quick disconnects are a unique feature of this system and are not normally found on most liquid oxygen systems. They enable the converter to be removed and installed on the aircraft with liquid oxygen in it. Other systems must be drained before this can be done.


TO OXYGEN REGULATOR
SUPPLY LINE RELIEF VALVE
VENT LINE
SUPPLY LINE QUICK DISCONNECT COUPLING
Supply Line Relief Valve
130psi
VENT

Supply Line Relief Valve and Warm-Up Coil.
Figure 5.

COMPONENTS

So far we have discussed the converter assembly and its components. Now let's look at the components of the oxygen system that are fixed to aircraft (see figure 5). The supply line relief valve is set at 130 psi and relieves excessive pressure in the supply line and warm-up coil (or warm-up plate). When the converter assembly is removed at the quick disconnects, oxygen is trapped in the supply line and warm-up coil and pressures may become excessive if the temperature changes. The supply line relief valve takes care of this. Also, if the container relief valve fails, the supply line relief valve will take over.

The purpose of the warm-up coil or plate is to raise the temperature of the gaseous oxygen to where it is suitable for breathing. The coil is usually in the cockpit or electronics compartment. Heat in the area surrounding the coil is transferred to the gaseous oxygen as it passes through the coil on its way to the regulators.

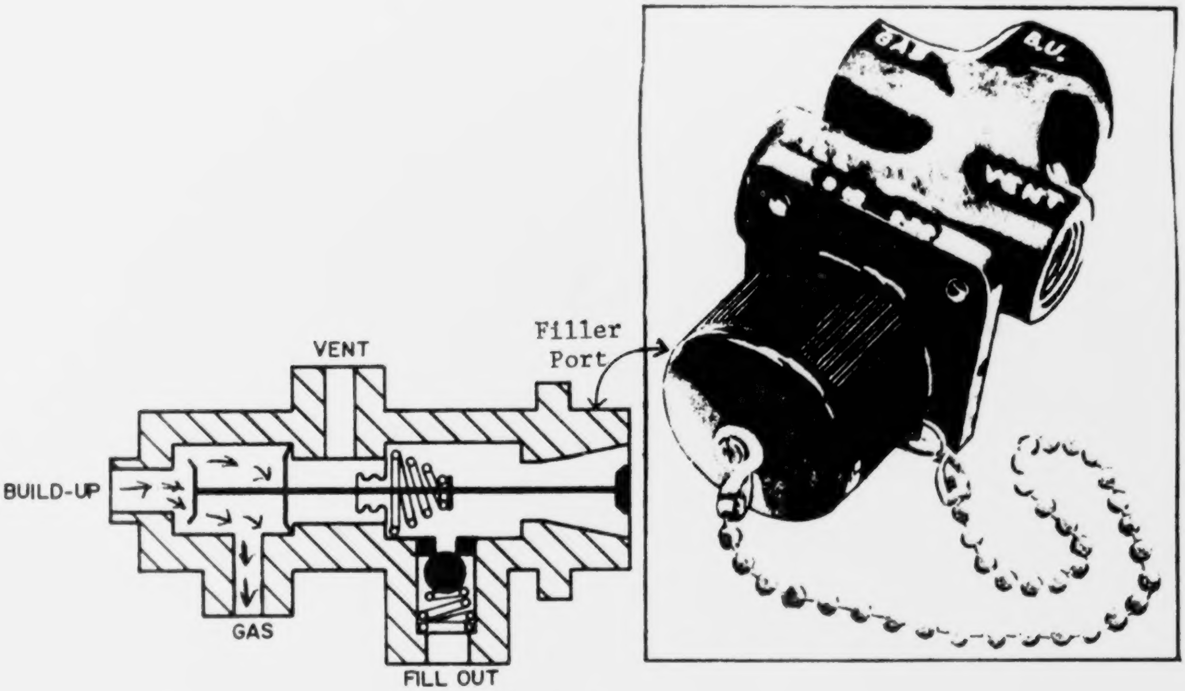


Figure 6.

COMBINATION VALVE

The combination fill, build-up, and vent valve shown (figure 6) is a dual function valve. On older oxygen systems, it would be divided into two separate valves (1) the fill valve and (2) the build-up and vent valve. The fill portion of the combination valve has a coupling for the filler nozzle of a LOX servicing cart to connect to. As shown in (figure 6) the valve is normally in the build-up position. The build-up port is connected to the pressure opening-pressure closing valve. Gaseous oxygen flows from the pressure opening-pressure closing valve through the build-up port into the combination valve. It then flows out of the gas port, back to the top of the container. The fill out port on the valve is connected to the bottom of the container. The ball check valve in this port prevents a reverse flow of liquid (from the bottom of the container) through the valve. A dust cap attached to a chain is used on the filler port of this valve. This cap protects the seal on the filler port from damage and contamination.

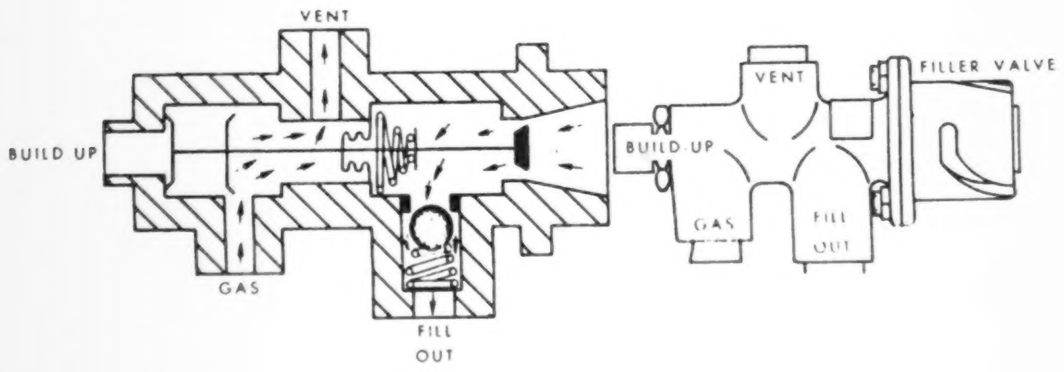

VENT
BUILD UP
GAS
FILL
OUT
VENT
FILLER VALVE
BUILD UP
GAS
FILL
OUT

Figure 7.

When the filler nozzle from the liquid oxygen servicing trailer is connected to the fill, build-up, and vent valve, it will be in the position shown below (figure 7). A pin in the filler nozzle pushes the valve shaft backwards and closes the build-up port. At the same time, the gas port is opened to the overboard vent and system pressure is discharged overboard. When the liquid flows in under pressure, it unseats the ball check valve in the "fill out" port and goes into the container. When the filler nozzle is removed, the ball check valve reseats, the valve shaft moves out and automatically returns the system to "build-up."

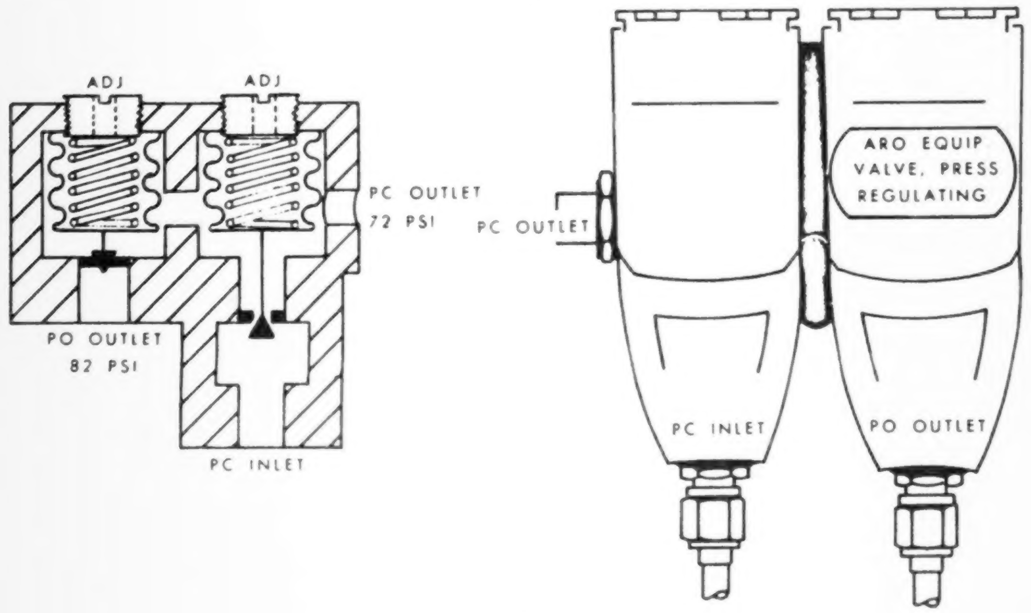
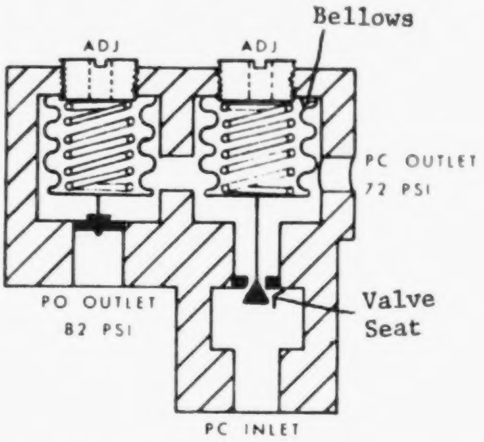

ADJ
ADJ
PC OUTLET
72 PSI
PO OUTLET
82 PSI
PC INLET
PC OUTLET
ARO EQUIP
VALVE, PRESS
REGULATING
PC INLET
PO OUTLET

Figure 8.

PRESSURE OPENING-PRESSURE CLOSING VALVE

The pressure opening-pressure closing valve is a single component that contains two separate parts (see figure 8). The pressure closing valve acts as the pressure regulator for the liquid oxygen system. It will either be preset at 70 psi or 300 psi depending upon the type of system the aircraft requires. The main purpose of the high pressure (300 psi) is to allow crew members to fill walk around bottles from the aircraft system. This means that bomber and cargo aircraft will have to use high-pressure systems.

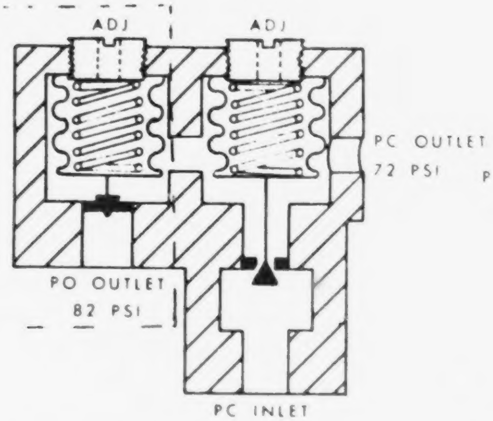


Combination Pressure Opening - Pressure Closing Valve

Figure 9.

PRESSURE CLOSING VALVE

Because the pressure closing valve is going to act as the pressure regulator for the system, its primary purpose is to maintain a constant head pressure on top of the liquid in the storage container. The head pressure (gas) is used to push the liquid out the bottom of the container and into the evaporator coil where it is converted to a gas. The bellows in the pressure closing valve (see figure 9) will sense the head pressure and open the valve if pressure drops below the valve setting (70 or 300 psi). When the valve opens, gaseous oxygen is transferred from the evaporation side of the system to the build-up side to maintain head pressure. The pressure closing valve is normally an open valve and is a part of the converter assembly.



Combination Pressure Opening -
Pressure Closing Valve

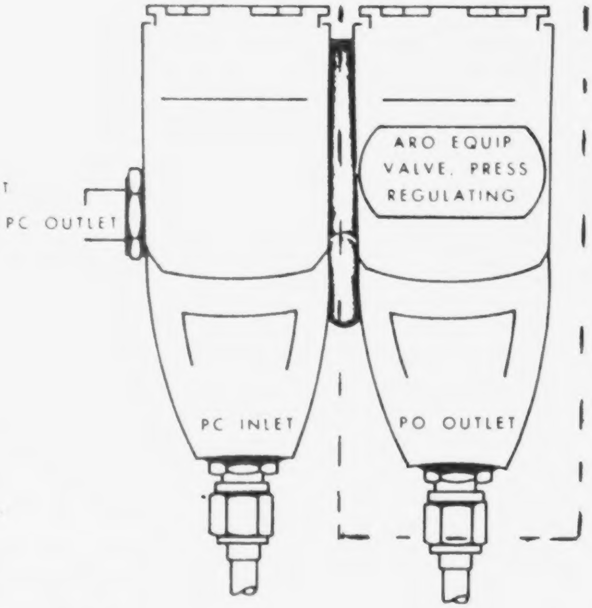


Figure 10.

PRESSURE OPENING VALVE

The pressure opening valve (PO) is the second portion of the pressure-opening-pressure-closing valve. Both valves (shown in figure 10) are bellows operated pressure regulating valves contained in one housing. As you already know the pressure-closing (PC) valve is a normally open valve that regulates system pressure to 70 psi by controlling the container "head pressure".

The presure-opening valve is normally closed. It will open when pressure in the system reaches 82 psi or above. The pressure opening valve's function is to conserve gaseous oxygen. When the pressure-opening valve opens gaseous oxygen is drawn directly from the top of the container by the breathing of the crew. This excess head pressure is used for crew breathing until system pressure drops below 82 psi. The pressure opening valve then closes and the system returns to normal.

> Note: Some systems do not have a combination pressure opening-pressure closing valve. These systems have a single pressure-closing valve. The pressure-closing valve in these systems, regulates pressure up to 82 psi. When the pressure in the system reaches 82 psi (or above) the excess pressure is vented overboard by a relief valve.

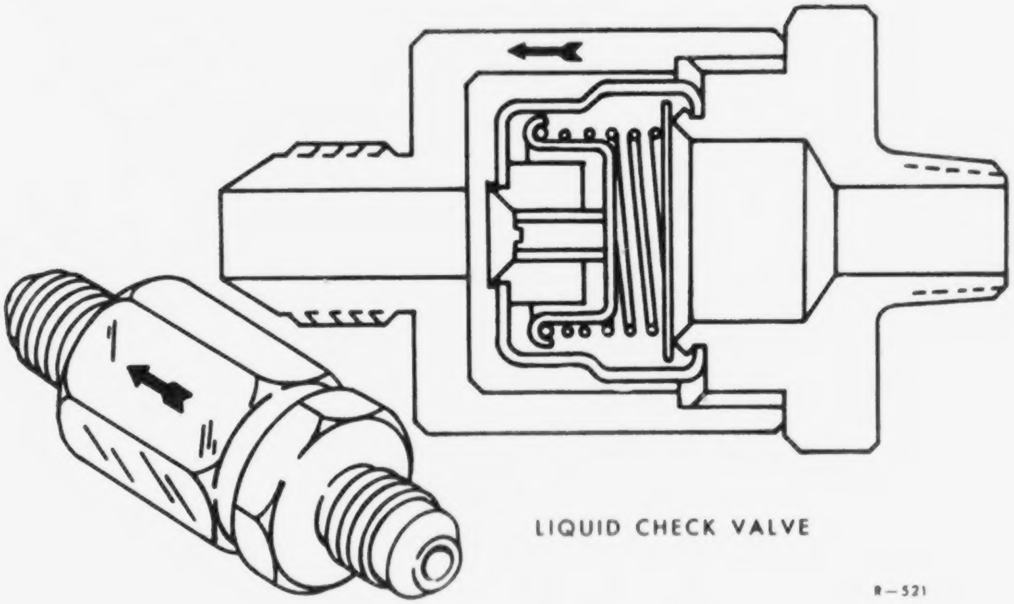


Figure 11.

LIQUID CHECK VALVE

The liquid check valve is especially made to work in a liquid oxygen system. From its place in the system, it will do two things: (1) It separates the liquid phase of operation from the gaseous phase. (2) It stops a reverse flow of gaseous oxygen (from the gaseous phase) back through the liquid container. During normal operation of the system, the liquid check valve allows liquid to be drawn from the bottom of the container into the evaporation coils in the direction of the arrow. As pressure in the build-up and evaporation sides changes because of use or liquid boil-off, the check valve will open and close at 5 psi below the container head pressure. This makes a 5 psi differential between the gaseous phase and liquid phase. When we discuss overall system operation, the function of the valve will become more clear.

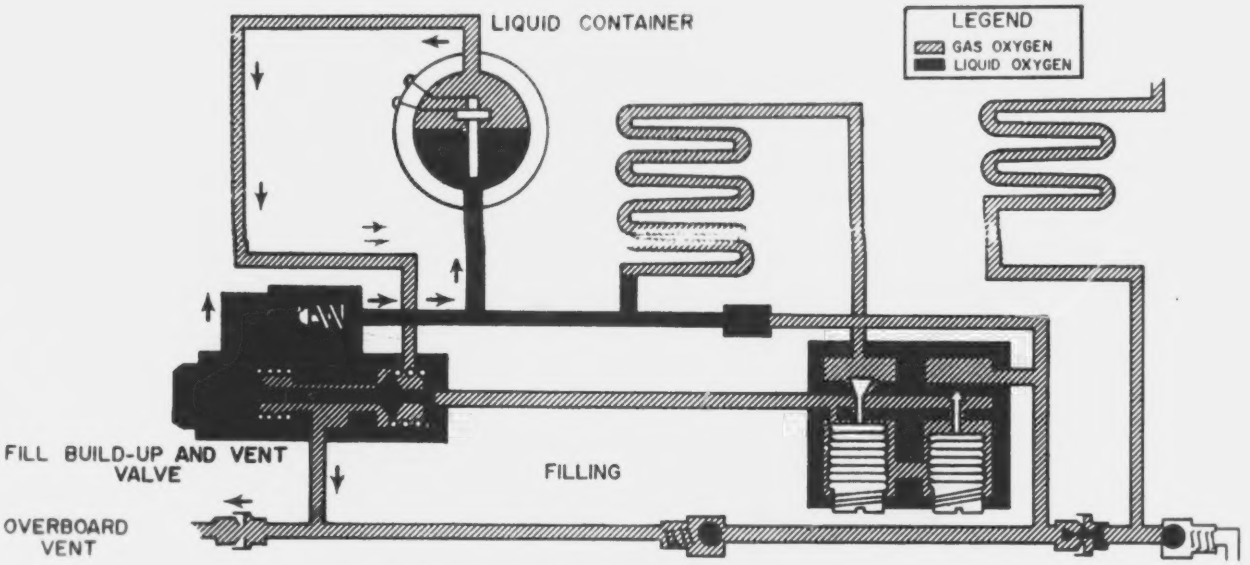


Figure 12.

FILL PHASE OF OPERATION

Now that you are familiar with the dual function valves used in this type of system, let's discuss the operation of this system (see figure 12). In order to fully understand what is taking place within the system, it is necessary to look at the system in three (3) different phases of operation. The first phase is FILLING and this is shown below. When the nozzle from the servicing trailer is connected to the fill, build-up and vent valve, the plunger in the valve is pushed in as shown. This closes the build-up line and provides an open line to the overboard vent. Any pressure in the system is now vented overboard. When the liquid oxygen enters the valve, it unseats the fill check valve and goes into the container through the bottom. When the container is full, liquid flows out the top of the container, back through the valve and out the overboard vent. At this time, the nozzle from the servicing trailer is removed and this automatically places the system in the build-up phase.

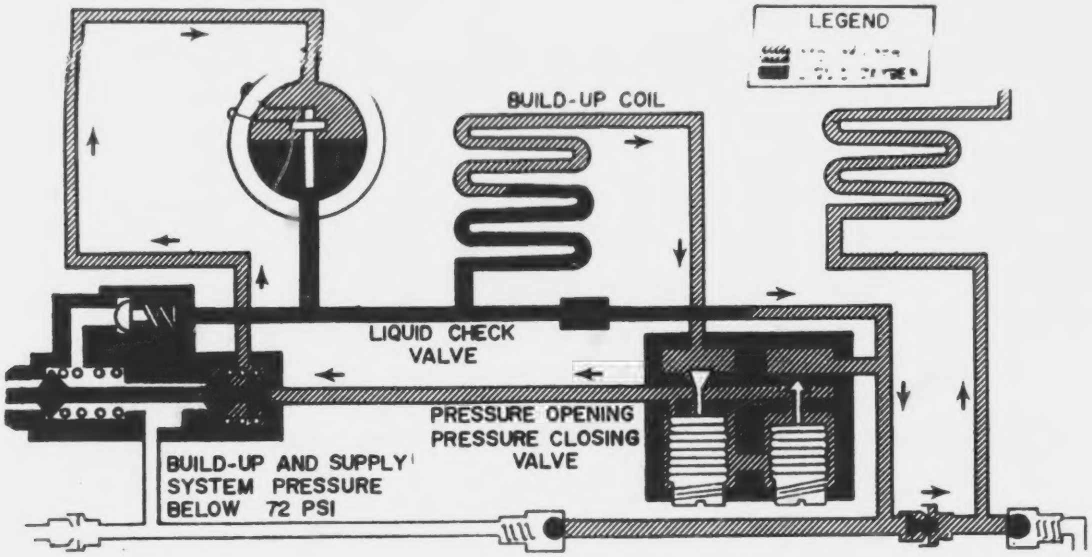

LEGEND
BUILD-UP COIL
LIQUID CHECK VALVE
PRESSURE OPENING PRESSURE CLOSING VALVE
BUILD-UP AND SUPPLY SYSTEM PRESSURE BELOW 72 PSI

Figure 13.

BUILD-UP PHASE OF OPERATION

Once the transfer hose nozzle is removed, pressure begins to build up in the system. This pressure build-up continues until system pressure reaches 72 psi. Figure 13 illustrates this pressure build-up phase. Note that liquid is boiling off in the build-up coil and returning to the top of the container through the pressure closing valve (which is open) and the fill, build-up and vent valve. The container is building up "head" pressure. During this phase, breathing oxygen is obtained from liquid oxygen drawn through the liquid check valve (shown open). This liquid will vaporize as it passes through the supply line and warm up coil on its way to the oxygen regulator.

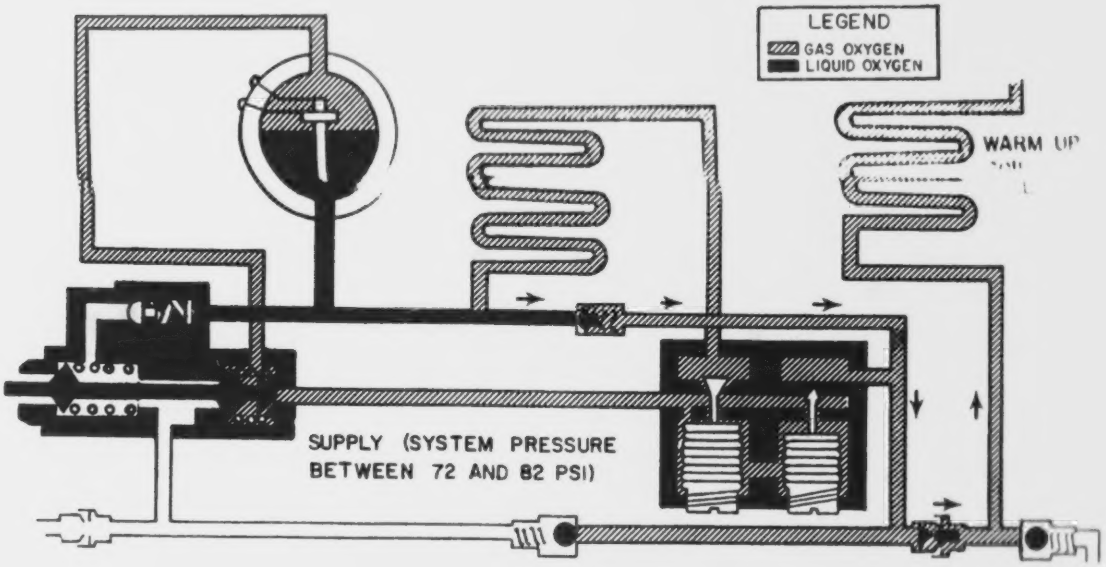


Figure 14.

GASEOUS OXYGEN DRAWN THROUGH LIQUID CHECK VALVE

In this phase of operation (shown in figure 14) breathing oxygen is obtained from gaseous oxygen drawn through the liquid check valve. In this condition the pressure-closing valve is closed (closed at 72 psi) and the pressure-opening valve is still closed (opens at 82 psi). With the pressure closing valve closed, pressure build-up in the system is stopped because the return path to the top of the container is blocked. The liquid trapped in the build-up coil now evaporates (shown evaporated) and causes a back flow of liquid to the container. This action is what enables gaseous oxygen to be drawn through the liquid check valve (see schematic). As the pressure is lowered by the oxygen being used, the pressure closing valve will open and pressure will again build-up.

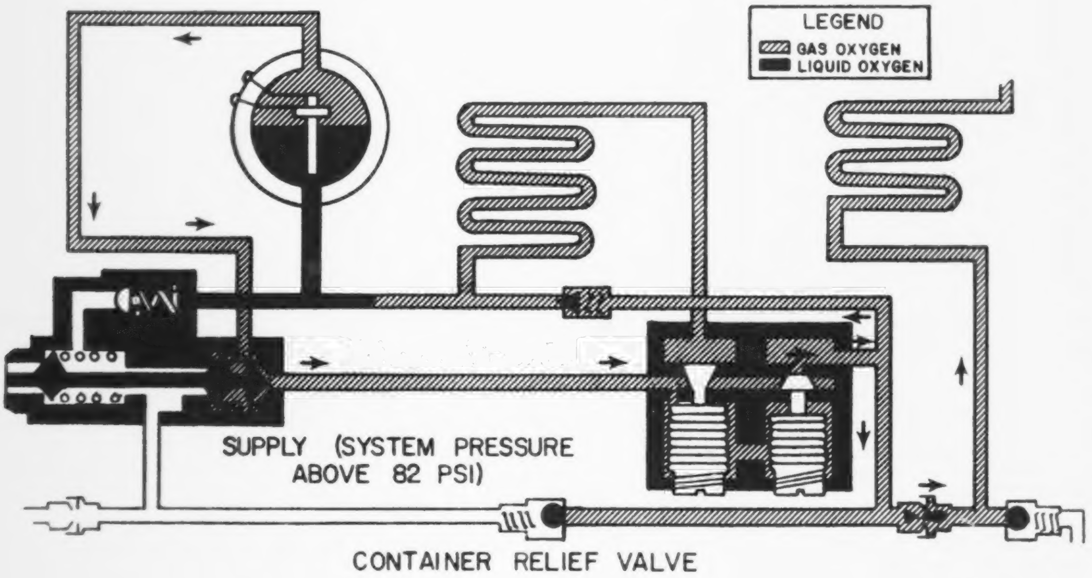


Figure 15.
SYSTEM OPERATION DURING LOW DEMAND

In cases where the use of gaseous oxygen is below normal as shown in (figure 15) at the regulator (low demand), and repeated cycling of the system causes excessive pressure build-up, the pressure opening valve will open. The pressure opening valve will open at 82 psi as shown below. When this valve opens, gaseous oxygen for breathing is drawn from the top of the container through this valve and out to the warm up coil. The pressure opening valve remains open as long as normal evaporation in the container is adequate to maintain system pressure above 82 psi. With this valve open, a back pressure will close the liquid check valve as shown. This phase of operation continues until system pressure drops below 82 psi again. When the oxygen system is not being used at all, normal evaporation in the container will cause pressure to build up until it reaches the setting of the container relief valve (110 psi). This will vent excess pressure overboard.

Instructions

The following page has a schematic (figure 16) of the liquid oxygen system we have been discussing. Use this page to do the following:

Part 1

Identify the components in the system by placing the letters from the arrowed circles by the correct name of that component in the given list. Check your answers on the following page.

Part 2

Draw the necessary valves open or closed (with a black pencil) to indicate the position they would take if the system pressure was above 82 psi. Now use a red pencil and trace in the liquid flow and a blue pencil to show gaseous oxygen flow. Check your tracing against the schematic for this phase of operation in the text.

1.____Vent Quick Disconnect.

2.____Fill,Build-Up,and Vent Valve.

3.____Fill Check Valve.

4.____Liquid Container.

5.____Build-Up Coil.

6.____Liquid Check Valve.

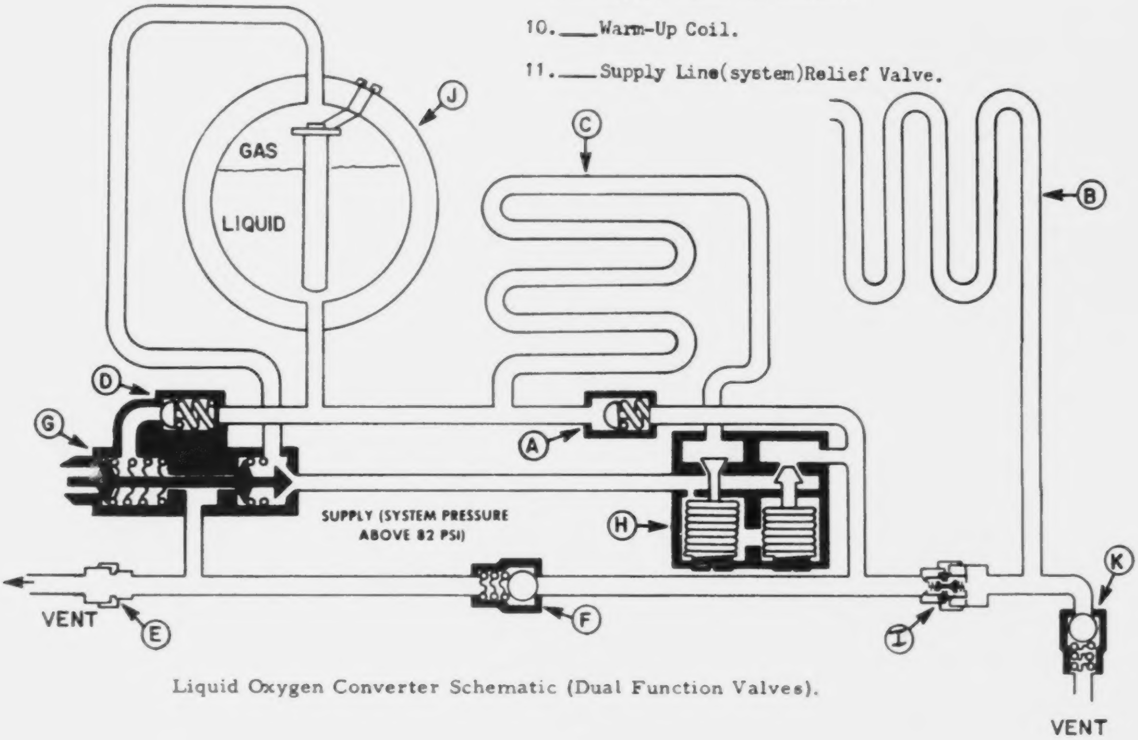
7.____Pressure Opening-Pressure Closing Valve.

8.____Container Relief Valve.

9.____Supply Quick Disconnect.

10.____Warm-Up Coil.

11.____Supply Line(system)Relief Valve.


J
GAS
LIQUID
C
B
D
G
A
H
SUPPLY (SYSTEM PRESSURE ABOVE 82 PSI)
VENT
E
F
I
K
VENT

Liquid Oxygen Converter Schematic (Dual Function Valves).

DISTRIBUTION SYSTEM

We have told how the LOX is stored and turned into gaseous oxygen. Now we will talk about the different ways this oxygen can be delivered to the crew by the regulators. Oxygen systems are usually referred to by the type of regulator installed in the distribution section of the system. If a system has a continuous flow regulator installed, it would be referred to as a continuous flow system, etc. There are three types of oxygen systems that we will discuss, the Demand, Pressure Demand, and Continuous Flow type systems.

DEMAND SYSTEM

The demand oxygen systems main component is the diluter demand regulator. The regulator gets its name from the fact that it delivers oxygen mixed with air, to your lungs, in response to the suction of your breath; that is, on demand. It will supply enough oxygen for all altitudes up to 35,000 feet. Each time you inhale, you close a valve in the mask and open a valve in the regulator. When you exhale, you reverse this process.

Below 34,000 feet the diluter feature of this regulator mixes suitable amounts of cabin air with 100% oxygen from the converter. This will conserve the oxygen from the converter. At altitudes above 34,000 feet, an aneroid (bellows assembly) will contract, closing the air inlet of the regulator, allowing only oxygen to be supplied to the mask. This is 100% oxygen from the converter. To get 100% oxygen below 34,000 feet, a diluter control on the regulator can be moved from the normal oxygen position to the 100% oxygen position.

> Note: This is normally done only to test and check the oxygen system, in an emergency, or under special circumstances such as, the treatment of wounded or shock victims. High altitude missions also call for 100% oxygen.

DILUTER DEMAND REGULATOR

The diluter demand regulator sends oxygen, or oxygen mixed with air, to the user on demand or when he breathes. This is all just fine until we reach a height of about 40,000 feet. From 40,000 feet up, the human body needs oxygen under pressure to work the way it should. At sea level pressure, carbon dioxide and water are stable in the blood stream and oxygen saturation of the blood is 100%. At low atmospheric pressure (high altitude), carbon dioxide and water vaporize in the lungs and pressure builds up that keeps oxygen from entering the lungs. By adding pressure to the oxygen (pressure breathing), we get rid of this pressure in the lungs and force the carbon dioxide out and force oxygen in. Look at figure 17 to see why different systems are required.

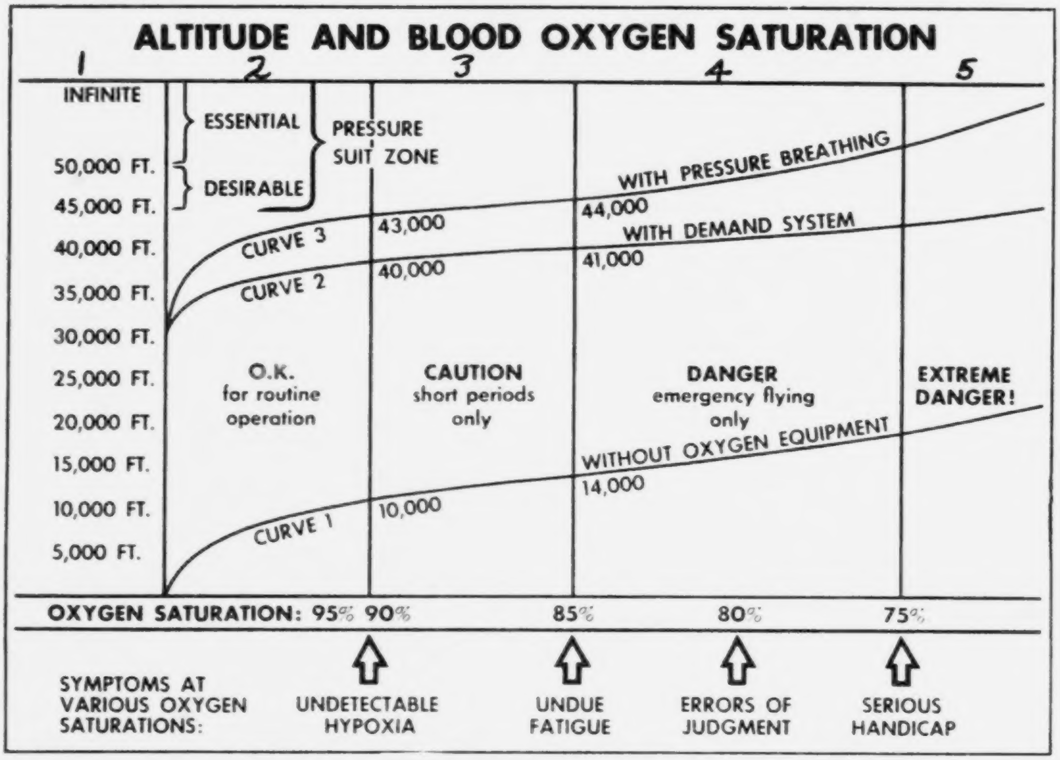


Figure 17.

PRESSURE DEMAND SYSTEM

With pressure breathing, as shown in the chart in the past frame, we are safe up to a height of about 50,000 feet. Above this height, the carbon dioxide and water vapor pressure will rise to a point where any more of an increase in oxygen pressure would damage the lungs. Also, above 50,000 feet, a pressure suit is needed in case cabin pressure is lost. Without any pressure blood will boil at 60,000 feet, so you can see the need of this equipment.

Now that you know why we need pressure breathing, let's talk about the pressure demand oxygen regulator. Below 35,000 feet the pressure demand oxygen regulator, functions as an ordinary demand regulator. Above 35,000 feet, the regulator has a positive pressure mechanism which comes into operation, either by manually positioning a dial on the regulator, or automatically by an aneroid in the regulator. This positive pressure mechanism will deliver oxygen to your lungs at a pressure slightly higher than that outside your body.

CONTINUOUS FLOW SYSTEM

Continuous flow or constant flow oxygen equipment is not used in any of the combat type aircraft. It is used in some of the training aircraft, and all cargo aircraft that take part in air evacuation and the transporting of troops and cargo. The crew, which is in the front part of the aircraft, uses the demand type oxygen regulator, while the cargo part in the rear of the aircraft uses the constant flow system. The main reason for this is that the constant flow system does not meet the needs of the crew. The supply for the constant flow system is the same as it is for the demand system, either the gaseous or the liquid may be used. There are two types of continuous flow regulators, the hand adjustment types and the automatic types.

CONTINUOUS FLOW REGULATOR

The hand adjustment type regulators are designed to deliver a continuous stream of oxygen, at a rate of flow, which is manually controlled. The pressure reducing mechanism and a needle valve control flow from the regulator. A pressure gage and flow indicator, calibrated in terms of altitude, are used to monitor flow from the regulator. Flow from the regulator is adjusted by turning the manual control knob until the reading of the flow indicator corresponds to the aircraft's altitude. If the aircraft is climbing at a rapid rate the flow indicator should be set about 5,000 feet above aircraft altitude.

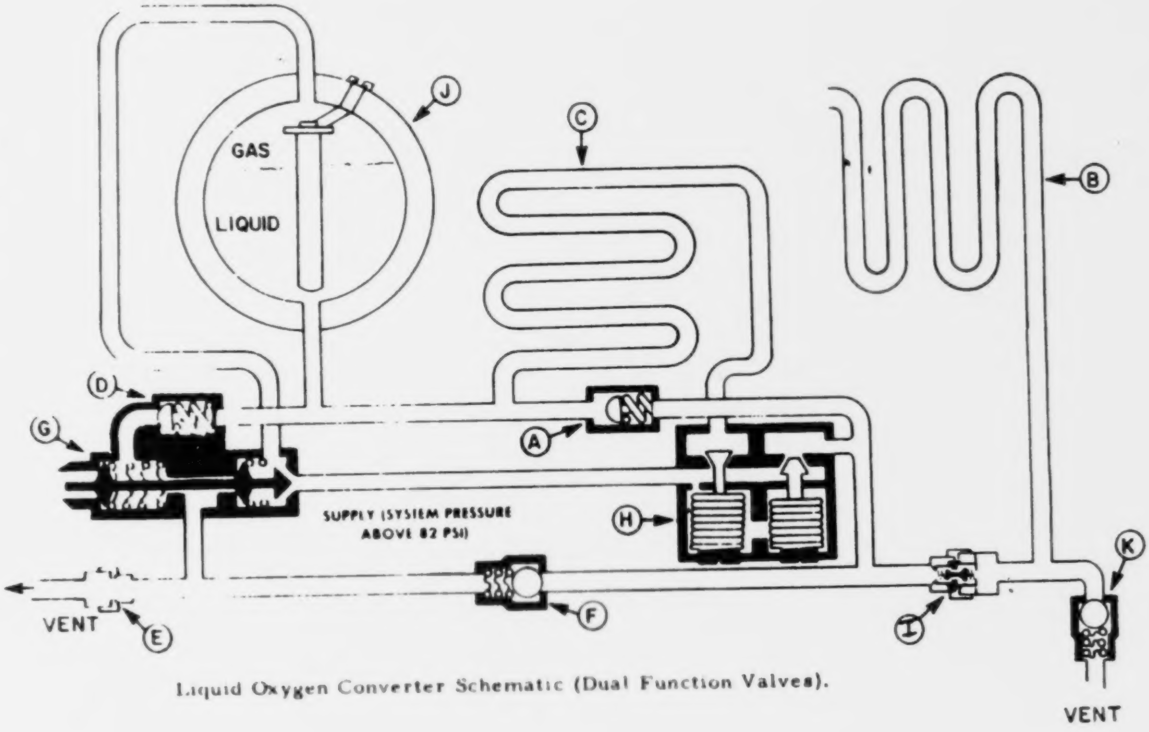
Automatic type continuous flow regulators are used in transport aircraft for supplying oxygen to passengers, troops or litter patients. The regulator supplies oxygen automatically, and is controlled by an aneroid for increasing oxygen flow with increasing altitude. It has no manual controls or flow indicators. The main disadvantage of a continuous flow system is it uses oxygen at a very rapid rate. One regulator can supply up to 100 passengers with oxygen. To insure the oxygen supply is not depleted, a crewmember must monitor pressure at frequent intervals, on a pressure gage installed in the distribution line. Only one pressure gage is installed in each passenger compartment.

Environmental Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-HO-402
27 January 1984

LIQUID OXYGEN SYSTEM

1. _____Vent Quick Disconnect.
2. _____Fill, Build-Up, and Vent Valve.
3. _____Ball Check Valve.
4. _____Liquid Container.
5. _____Build-Up Coil.
6. _____Liquid Check.
7. _____Pressure Opening-Pressure Closing Valve.
8. _____Container Relief Valve.
9. _____Supply Quick Disconnect.
10. _____Warm-Up Coil.
11. _____Supply Line (System) Relief Valve.


J
GAS
LIQUID
C
B
D
G
A
H
SUPPLY (SYSTEM PRESSURE ABOVE 82 PSI)
K
VENT
E
F
I
VENT

Liquid Oxygen Converter Schematic (Dual Function Valves).

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Designed for ATC Course Use. Do Not Use on the Job.

Environmental Pneudraulics Branch
Chanute AFB, Illinois

3ABR42331-HO-402
12 August 1980

FOREIGN OBJECT DAMAGE PREVENTION AND COMPOSITE TOOLKITS (CTK)

Dollars out of your pocket!!! Sounds drastic, doesn't it? Everyday throughout the military, thousands of dollars are wasted through foreign object damage (FOD). These initials - FOD - are probably new to you, but during your stay in the Air Force they will become familiar to you.

Foreign Object Damge is caused by a variety of things, mostly man-made. A mechanic installs a new engine bleed valve. During his installation he drops a 1/4" bolt (sounds pretty small, right?). In his haste to complete the job, he fails to check the area for FOD items. This small 1/4" bolt is eaten by the engine. Engines, you will find, have a big appetite; they will eat anything that can pass their inlet -- bolts, nuts, safety wire, tools, rocks, even ear defenders and hats. The bolt, while being digested by the engine, nicks two compressors and three turbine blades. This damage does not become known until the pilot advances the throttles on takeoff. The turbine blades crack, causing the engine to be out of balance. The engine disintegrates, rupturing the fuel cells. Scratch one aircraft and eight people (four crew members and a family of four) as the aircraft crashes on a highway two miles from the end of the runway. Although this is fictitious, incidents such as this have happened and will continue, unless we all practice good FOD prevention.

In dollars alone, we spend millions that need not be spent from damage caused by foreign objects. In 1976, SAC spent over a million dollars due to FOD. This includes damaged engines, tires, equipment and personal injuries.

We all complain about spending our money, especially when we have nothing to show for it. FOD is a major drain on your pocket. Being in the Air Force you tend to lose twice. How? First, your tax dollars must be used to remedy FOD; they must pay to replace or repair items damaged by FOD. Secondly, since the Defense budget is fixed (you get a set amount to operate on for one year), the more you spend needlessly, the less you have to operate on daily. As an example of this, if a B-52 tire is damaged by FOD, $280.00 is spent out of the Air Force budget. This is $280.00 less you'll have to spend on new equipment to make your job a little easier. It is really a needless expense, so practice good FOD prevention; it makes good sense!

While doing your projects, you will be required to practice FOD prevention. This means you will use care not to allow nuts, bolts, safety wire, etc., to be left in your work area when you complete your assigned job. Use the magnet provided to remove all traces of FOD.

Supersedes 3ABR42331-HO-402, 30 June 1978.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 400; TTVSA - 1
Designed for ATC Course Use. Do Not Use on the Job.

Clean up your project area. If your instructor finds FOD items during his inspection of your project, you will be required to reaccomplish the project. This is treated the same as a technical error and a failure will be entered in your progress record. Get used to it now, since it will become a part of your everyday life during your Air Force career.

While you are doing your projects, you will also use a consolidated toolkit (referred to as a CTK). The CTK program is one of many integral parts of the FOD program. This kit is a quick means of identifying lost or misplaced tools. They are made in many forms, such as bags, shadow boards, metal and wooden boxes. Some are even designed to fit into briefcases.

A CTK is one of these containers mentioned and is usually filled with strips of styrofoam or some type of spongy material. A silhouette of that tool is cut out and usually painted a specific color. The tools required to do the job are then placed in the container. This is done so that any shortage can instantly be identified.

If any shortage does occur, you can easily find the tool since you have not left the job. You must backtrack until you find the tool. This will prevent FOD and perhaps save thousands of dollars in FOD damage.

PROGRAMMED TEXT

3ABR42331-PT-402A

Technical Training

Aircraft Environmental Systems Mechanic

AIRCRAFT LIQUID OXYGEN SYSTEMS BASIC SYSTEM WITH SINGLE FUNCTION VALVES

26 February 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

RGL: 9.9

OBJECTIVE

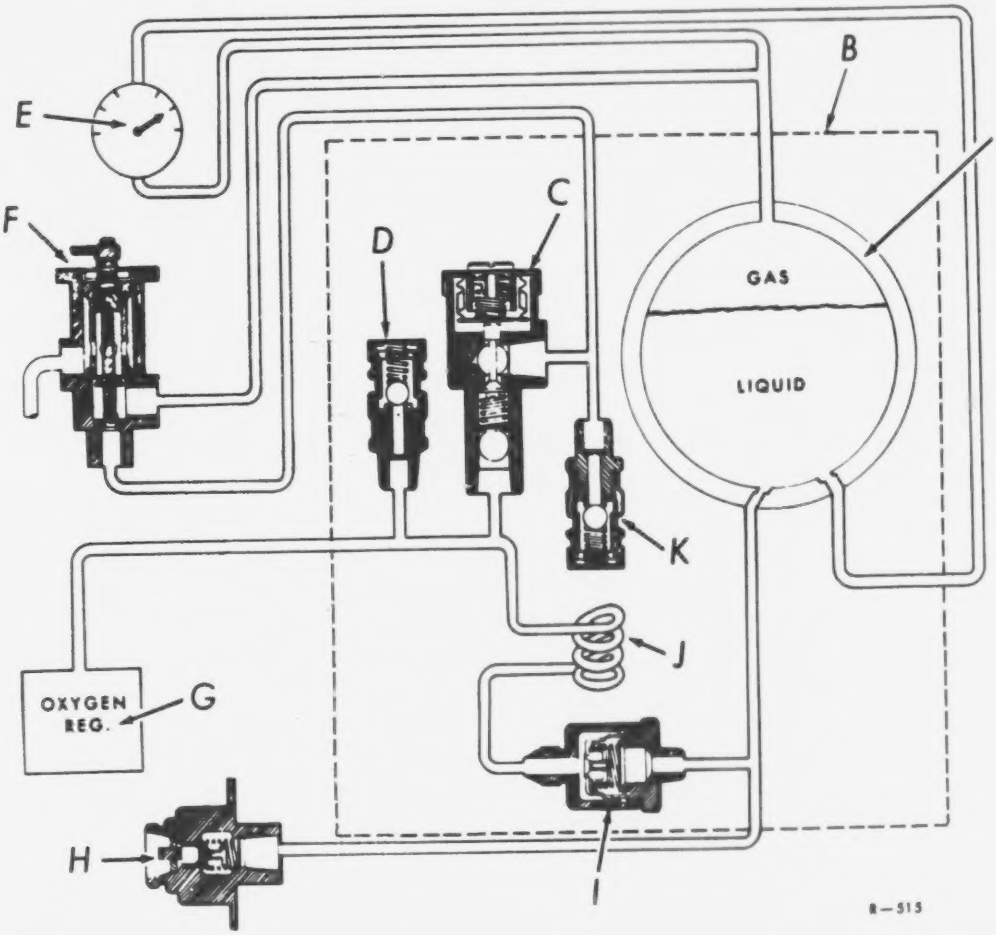
Relate four of five basic liquid oxygen system components to their operation.

INSTRUCTIONS

As you read and study each frame in this programmed text, locate in the classroom the particular component or system you are reading about. Each individual part and a complete system on a trainer will be available for you to see and inspect. Also, after each frame you will find a number of statements and you are asked to select the true statement or statements from this list. Read the material carefully before making a selection. If you select the correct answers, continue to the next frame. If you are wrong or in doubt, read the material again and correct yourself before continuing. The answers to the statements can be found on the top of the next page.

Supersedes 3ABR42331-PT-402A, 16 November 1978.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; TTVSA - 1

Shown below is a basic liquid oxygen system. It consists of a converter assembly (B) which includes everything inside the dashed lines, a filler valve (H), a buildup and vent valve (F), contents gage (E), oxygen regulator (G), and the tubing and fittings required to connect these components together. This basic system has single function valves (valves that have only one purpose). In other systems we have dual function or combination valves that serve more than one purpose. All of these components will be discussed one at a time in this text and will be available in the classroom for you to see and inspect. Review the schematic shown and identify all the components.

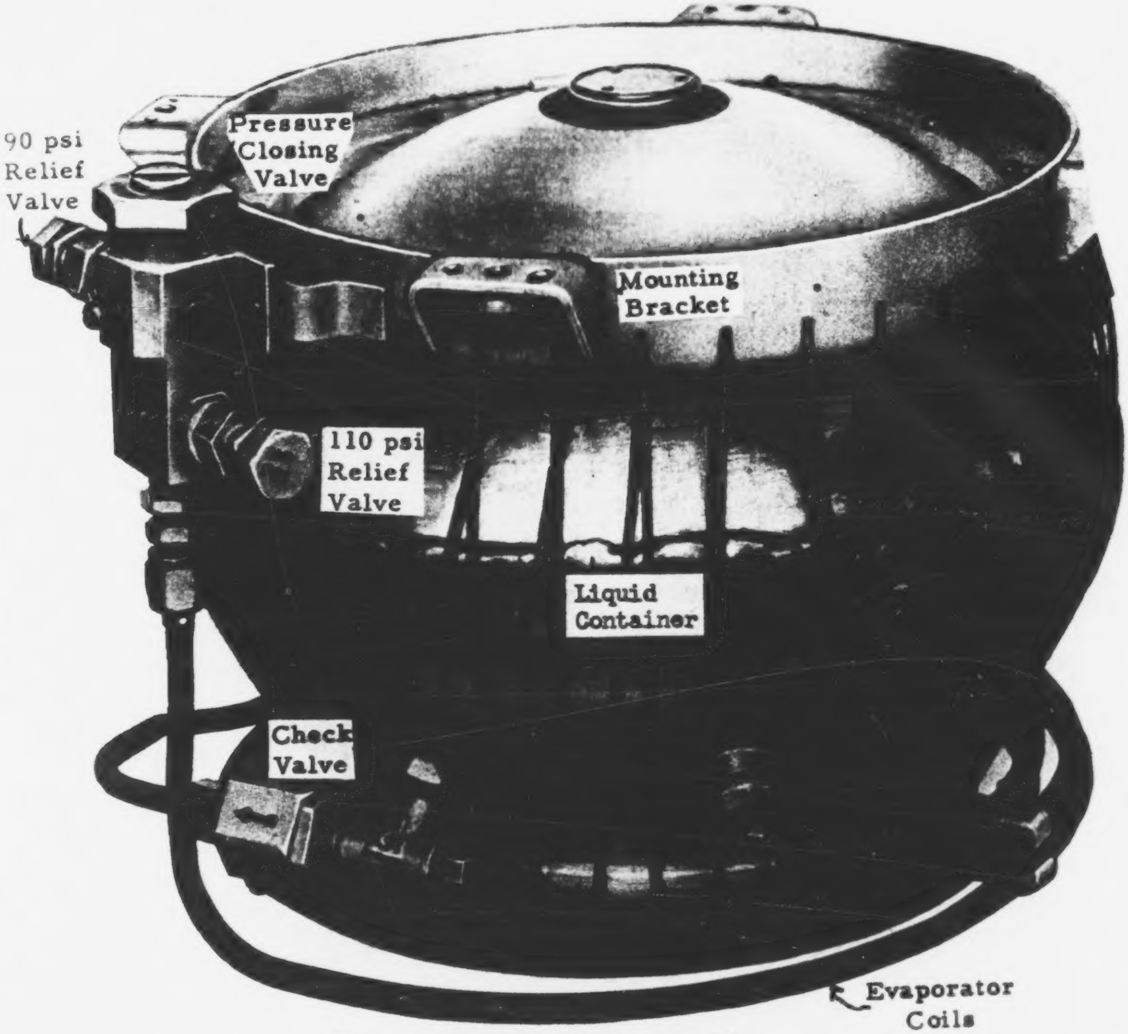


Aircraft Liquid Oxygen System (Single Function Valves).

No Response Required

Frame 2

The liquid oxygen converter assembly is the heart of the liquid oxygen system. This is a multi-function unit that is designed to receive and store the liquid, pressurize the liquid, convert the liquid to a gas (or allows it to be converted), and supply the gas at a constant pressure to the oxygen regulators. Once the liquid container is filled and the system is placed in operation, the conversion from liquid to gas is automatic as long as the gas is being used and as long as the liquid lasts.


90 psi Relief Valve
Pressure Closing Valve
Mounting Bracket
110 psi Relief Valve
Liquid Container
Check Valve
Evaporator Coils

Five Liter Converter Assembly.

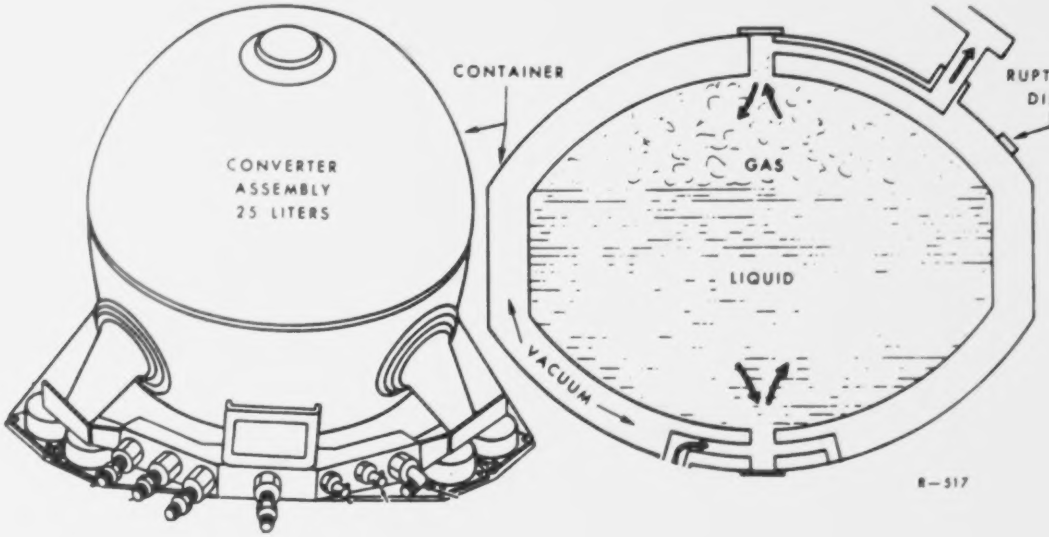
Check the following statements that are true.

_____1. The converter assembly stores, pressurizes and converts the liquid to gas.
_____2. The converter assembly is the heart of the liquid oxygen system.
_____3. The converter assembly operates automatically once its filled and the system is placed in operation.

Answers to Frame 2. 1. ✓ 2. ✓ 3. ✓

Frame 3

The largest part of the converter assembly is the liquid container. This is a double walled, vacuum insulated unit similar to the common "Thermos" bottle. It is also known as a "Dewar" flask after its inventor. As shown below, the liquid is stored in the inner shell and a vacuum separates it from the outer shell. The outer shell has a rupture disc that will blow out to prevent an explosion if the inner shell develops a leak. The rupture disc will blow at 30 psi. Liquid containers vary in size from 5 to 75 liters capacity.



Check the following statements that are true.

_____1. The container is double walled and vacuum insulated.

_____2. The rupture disc will blow at 30 psi.

_____3. Containers range in size from 5 to 75 liters capacity.

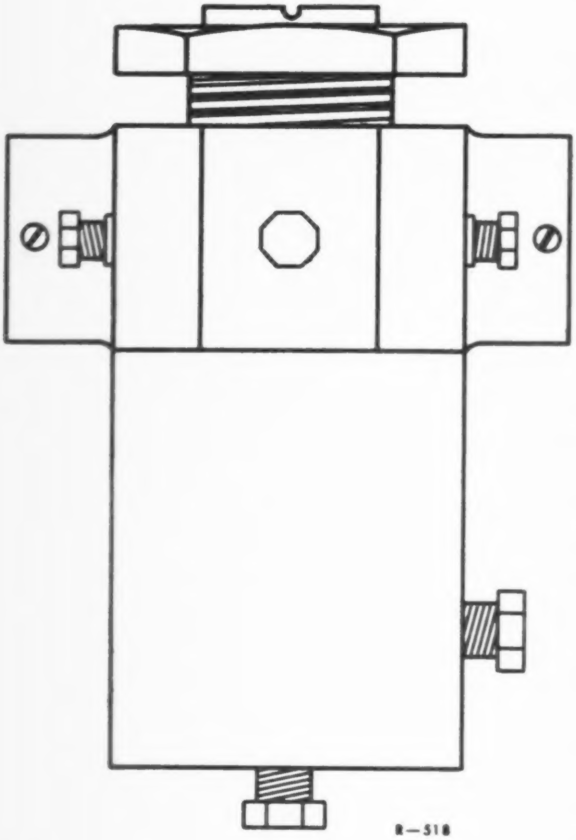
_____4. Liquid oxygen is stored in the vacuum area of the container.

_____5. The largest part of the converter assembly is the liquid container.

Answers to Frame 3. 1. ✓ 2. ✓ 3. ✓ 4. ___ 5. ✓

Frame 4

The pressure closing valve acts as the pressure regulator for the liquid oxygen system. It will either be preset at 70 psi or 300 psi depending upon the type of system the aircraft requires. The main purpose of the high pressure (300 psi) is to allow crew members to fill walk-around bottles from the aircraft system. This means that aircraft like the B-52 and KC-135 would have a high-pressure system.



Pressure Closing Valve

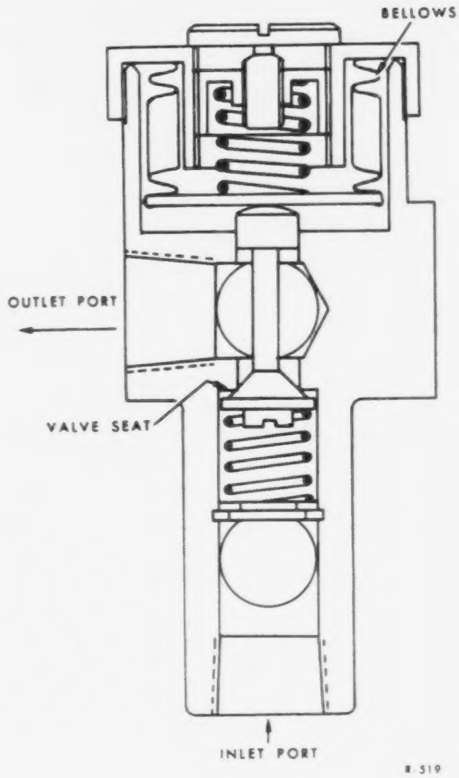
Check the following statements that are true.

_____1. The pressure closing valve acts as a pressure regulator.
_____2. Fighter aircraft would require a high-pressure liquid oxygen system.
_____3. The pressure closing valve is set at 70 or 300 psi.
_____4. The main reason for having a high-pressure liquid oxygen is to fill walk-around bottles.
_____5. The low-pressure liquid oxygen system operates at 70 psi.

Answers to Frame 4. 1. ✓ 2. ___ 3. ✓ 4. ✓ 5. ✓

Frame 5

Because the pressure closing valve is going to act as the pressure regulator for the system, its primary purpose is to maintain a constant head pressure on top of the liquid in the storage container. The head pressure (gas) is used to push the liquid out the bottom of the container and into the evaporator coil where it is converted to a gas. The bellows in the pressure closing valve (see illustration) will sense the head pressure and open the valve if pressure drops below the valve setting (70 or 300 psi). When the valve opens, gaseous oxygen is transferred from the evaporation side of the system to the build-up side to maintain head pressure. The pressure closing valve is part of the converter assembly.



Check the following statements that are true.

_____1. The pressure closing valve maintains a constant head pressure.
_____2. The pressure closing valve is part of the converter assembly.
_____3. The pressure closing valve acts as the system pressure regulator.
_____4. The head pressure (gas) pushes the liquid out of the container.
_____5. The pressure closing valve transfers liquid oxygen in the system.

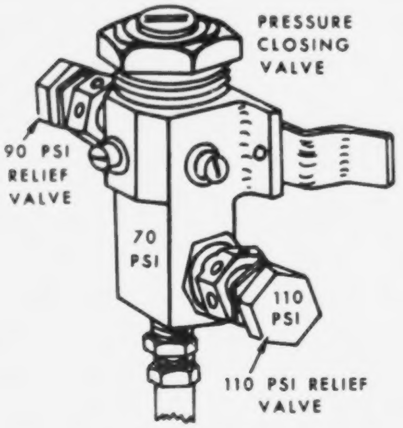
Answers to Frame 5. 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5. ____

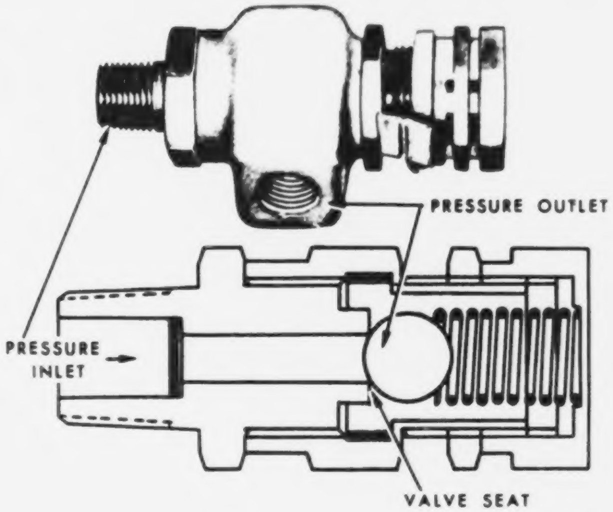
Frame 6

In our basic oxygen system we have two (2) relief valves. One valve is in the build-up side of the system and relieves excessive head pressure from the container. This valve is set to open at 90 psi in the 70 psi system and 345 psi in the 300 psi system.

The second relief valve is in the evaporation side of the system (or distribution side) and protects it from excessive pressure. This valve is set to open at 110 psi in a 70 psi system and 395 psi in the 300 psi system.

Both of the relief valves are screwed into the pressure closing valve, one on each side. The relief valves are also part of the converter assembly.


PRESSURE CLOSING VALVE
90 PSI RELIEF VALVE
70 PSI
110 PSI
110 PSI RELIEF VALVE


PRESSURE OUTLET
PRESSURE INLET
VALVE SEAT

R-520

Check the following statements that are true.

_____1. The relief valve in the build-up side relieves excessive head pressure.

_____2. The 110 psi relief valve is in the build-up side.

_____3. The relief valves are screwed into the pressure closing valve.

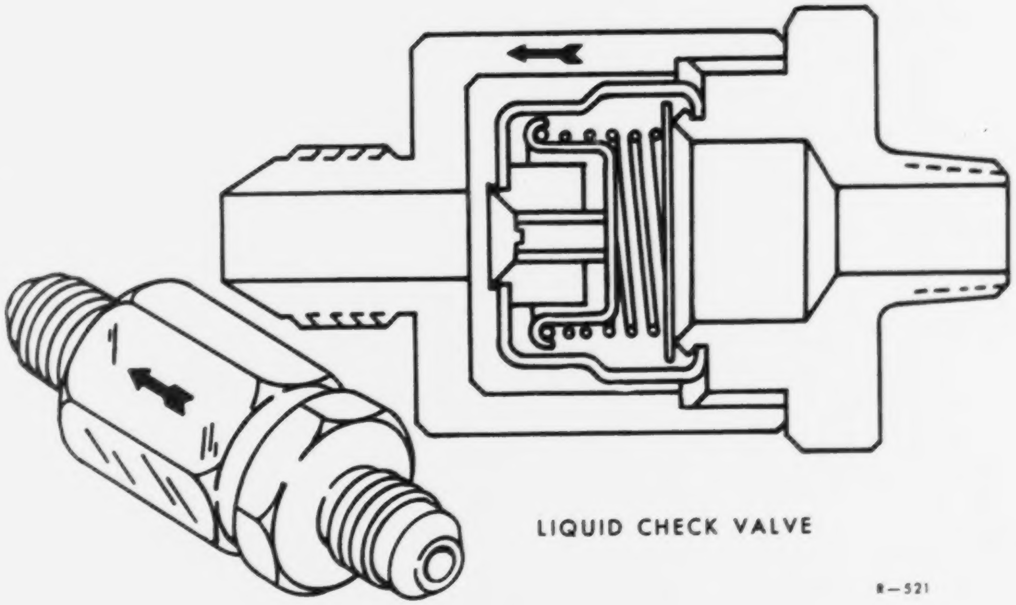
_____4. The evaporation side contains the 110 psi relief valve.

_____5. The 345 and 395 psi relief valves are found in the 300 psi system.

Answers to Frame 6. 1. ✓ 2. ____ 3. ✓ 4. ✓ 5. ✓

Frame 7

The liquid check valve is especially designed to operate in a liquid oxygen system. From its position in the system it will accomplish two things:
1. It separates the liquid phase of operation from the gaseous phase.
2. It prevents a reverse flow of gaseous oxygen (from the gaseous phase) back through the liquid container. During normal operation of the system, the liquid check valve allows liquid to be drawn from the bottom of the container into the evaporation coils in the direction of the arrow. As pressure in the build-up and evaporation sides change because of use or liquid boil-off, the check valve will open and close at 5 psi below the container head pressure. This creates a 5 psi differential between the gaseous phase and liquid phase. When we discuss overall system operation, the function of the valve will become more clear.



LIQUID CHECK VALVE

8—521

Check the following statements that are true.

_____1. The check valve separates the liquid and gaseous phase of system operation.

_____2. The liquid check valve is especially designed for liquid oxygen systems.

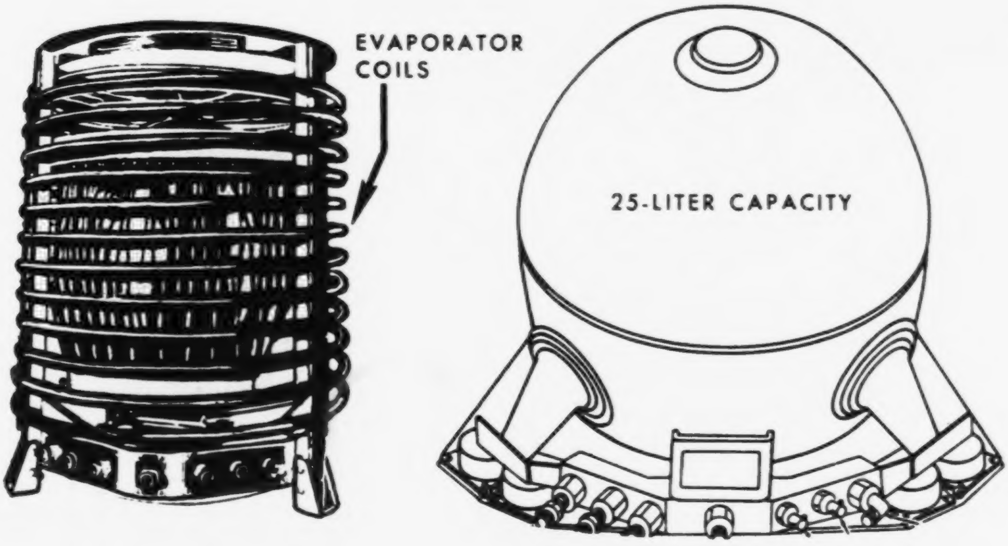
_____3. The check valve opens or closes at 5 psi below container head pressure.

_____4. When the check valve closes, it prevents reverse flow.

Answers to Frame 7. 1. ✓ 2. ✓ 3. ✓ 4. ✓

Frame 8

The evaporating coil is made of aluminum alloy and mounted surrounding the liquid oxygen container. This coil presents a large surface area which allows the liquid oxygen to evaporate and turn into a gas. Keep in mind, though, that all converters do not have such a coil. When converters are used in large aircraft where the tubing runs are comparatively long, the evaporator coil is not necessary. The long tubing runs provide the necessary heat-exchanging tubing surface area for evaporation of the liquid oxygen. Note the converter assembly shown on the right below does not have an evaporating coil. In the complete oxygen system, the regulators are connected to the other end of the evaporating coil.



R-522

Check the following statements that are true.

_____1. The liquid changes to a gas in the evaporating coil.

_____2. The evaporation coil can be part of the converter assembly.

_____3. The oxygen regulator is part of the converter assembly.

_____4. The evaporation tubing allows the gaseous oxygen to heat up.

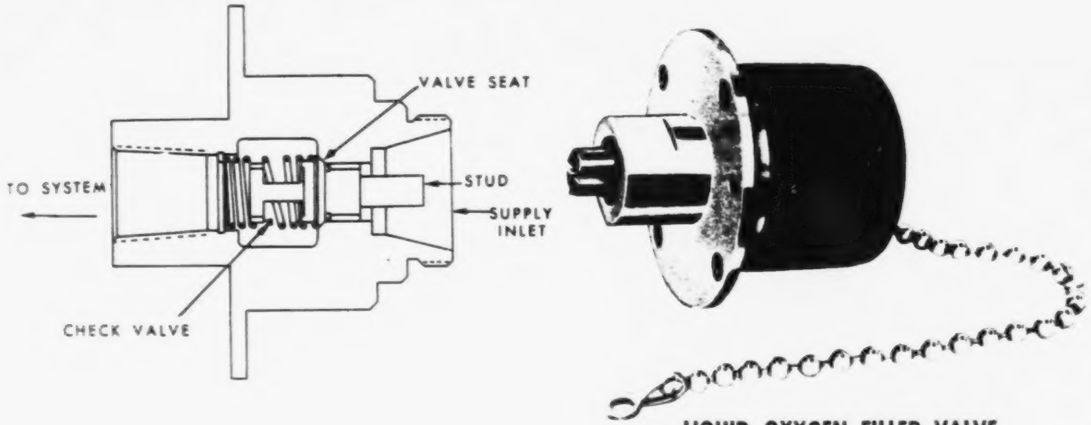
_____5. In large aircraft, an evaporator coil is not always necessary.

Answers to Frame 8. 1. ✓ 2. ✓ 3. ___ 4. ✓ 5. ✓

Frame 9

The filler valve (shown below) is provided for the purpose of filling the system with liquid oxygen. The filler valve is basically a spring loaded check valve assembly with a protective (dust) cap. This valve is also designed for a quick-disconnect coupling with the recharging hose nozzle. When the dust cap is removed from the supply inlet, the supply source (recharging hose) is connected by pushing the nozzle on the valve and making a half-turn. The nozzle on the servicing hose pushes in the stud on the filler valve and unseats the spring loaded check valve and liquid flows in. When the servicing hose is removed, the spring reseats the valve. If an aircraft has more than one converter, each converter will have its own filler valve.

100



LIQUID OXYGEN FILLER VALVE

R-523

Check the following statements that are true.

_____1. The dust cap prevents the filler valve from leaking.

_____2. One filler valve is needed for each converter.

_____3. The filler valve is basically a spring loaded check valve.

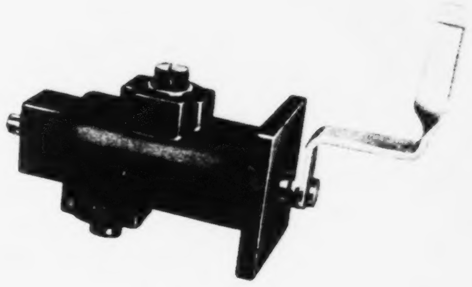
_____4. The filler valve is designed for a quick-disconnect with the servicing hose nozzle.

_____5. When filling the system, the servicing hoze nozzle reseats the check valve.

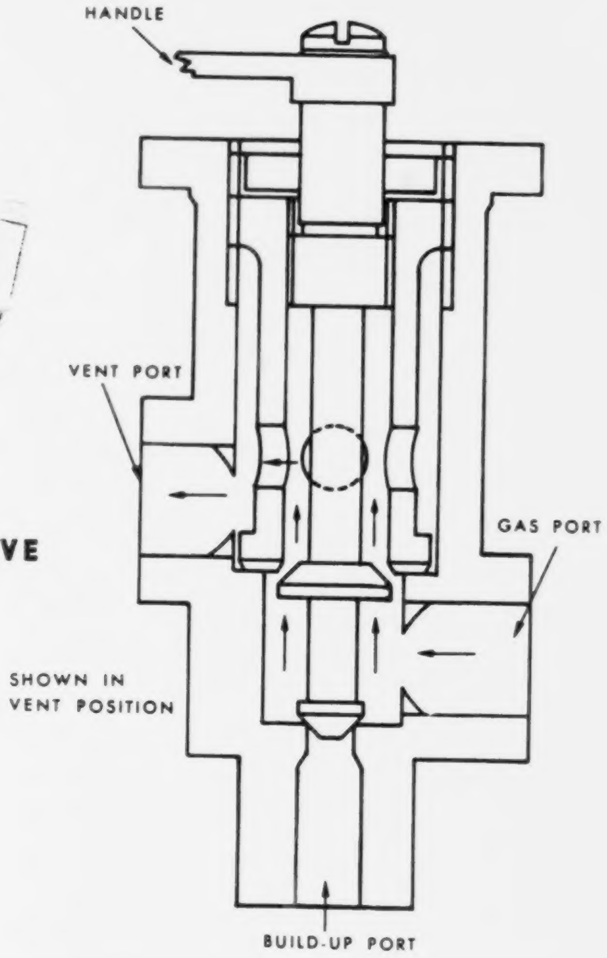
Answers to Frame 9. 1. ____ 2. ✓ 3. ✓ 4. ✓ 5. ✓

Frame 10

The build-up and vent valve (shown below) is a manually operated, two-way rotary valve. When the handle is turned to the "VENT" position, the top of the converter is vented to the atmosphere. In this position, the gas port (from the top of the converter) is now open to the vent port and the build-up port is closed. When the handle is rotated to the "BUILD-UP" position, the gas port is open to the build-up port and the overboard vent port is closed. As with the filler valve, the name of this valve states its purpose; it allows the converter head pressure to "build-up" or be "vented" overboard.



BUILD-UP AND VENT VALVE



Check the following statements that are true.

_____1. The build-up and vent valve is a manually operated valve.

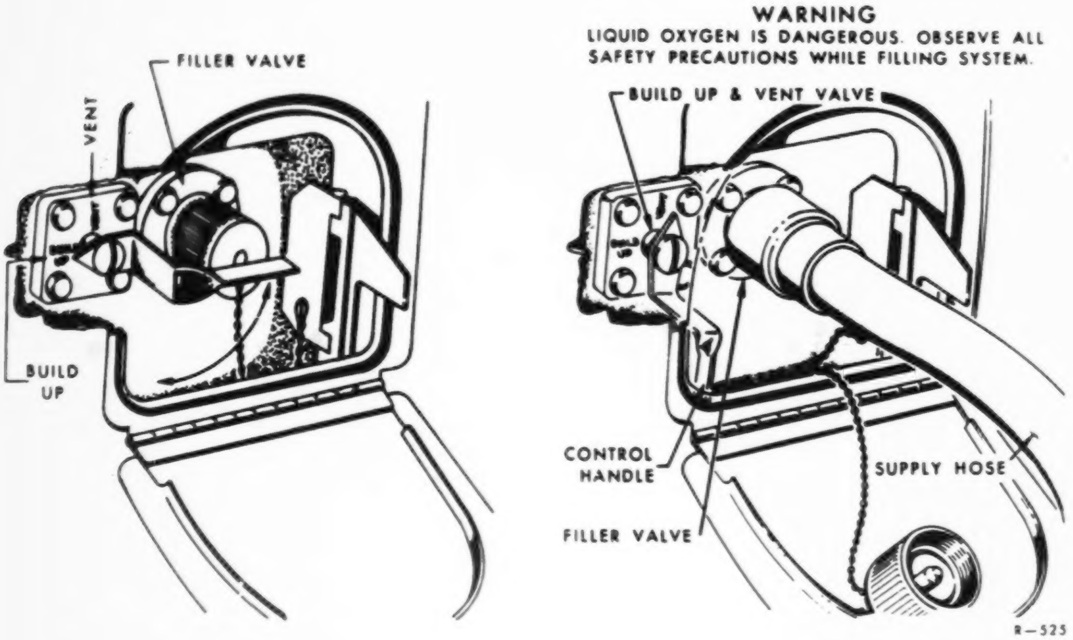
_____2. In "vent," the system will not contain any pressure.

_____3. In "build-up," converter head pressure is trapped and system pressure will rise.

Answers to Frame 10. 1. ✓ 2. ✓ 3. ✓

Frame 11

On the aircraft, the filler valve and build-up and vent valve are located side by side as shown below. When the build-up and vent valve is in "BUILD-UP," the control handle covers the filler valve dust cap and it cannot be removed. This insures that the servicing hose will not be connected with pressure in the system. When servicing the converter, the valve must be in "VENT" as shown on the right. On the other hand, the valve must be in "BUILD-UP" for the pilot to receive oxygen. To insure the valve is in build-up before the aircraft takes-off, the access door (filler well door) is designed so it cannot be closed when the valve handle is in "VENT."


WARNING
LIQUID OXYGEN IS DANGEROUS. OBSERVE ALL SAFETY PRECAUTIONS WHILE FILLING SYSTEM.

Check the following statements that are true.

_____1. In order to connect the servicing hose, the valve must be in "VENT."

_____2. When the aircraft is flying, the valve must be in "VENT."

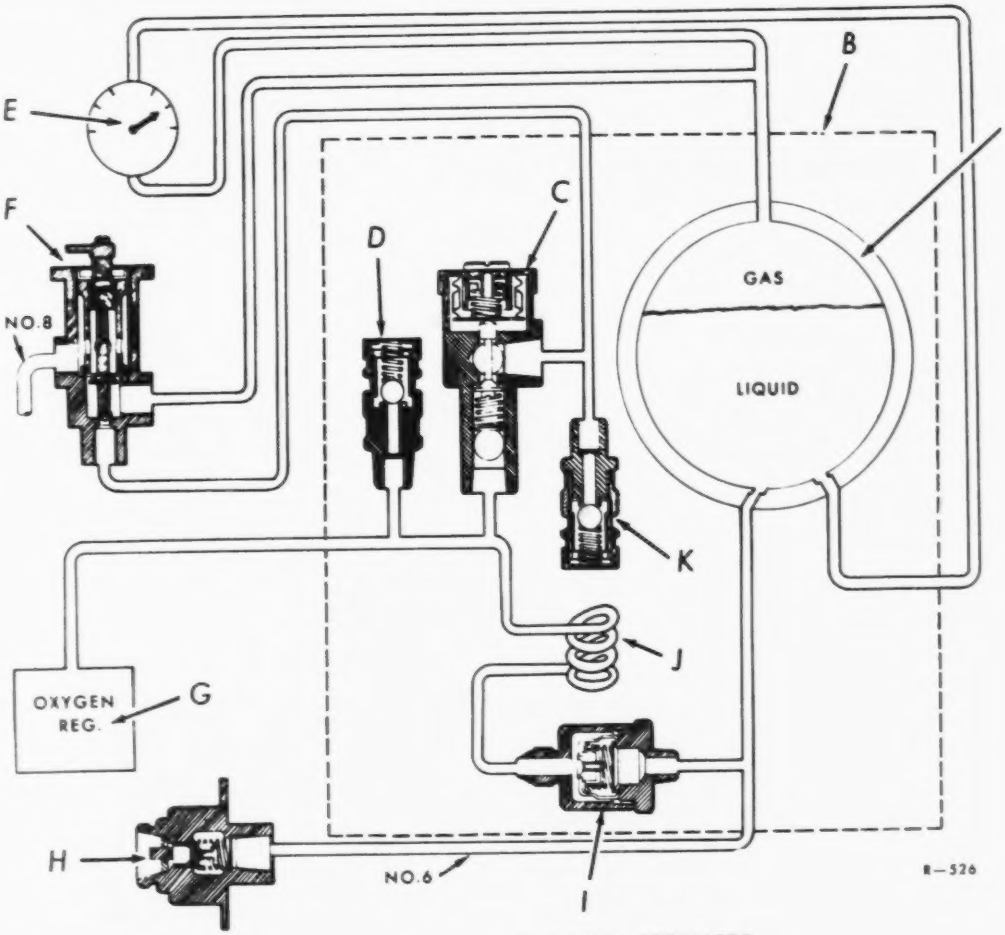
_____3. When the valve is in build-up, the filler valve dust cap cannot be removed.

_____4. With the valve in the "vent" position, the access door cannot be closed.

Answers to Frame 11. 1. ✓ 2. ____ 3. ✓ 4. ✓

Frame 12

The tubing (plumbing) used in the liquid oxygen system is aluminum alloy. Also, all of this aluminum tubing will be No. 5 (5/16) except in the following places: 1. The line from the filler valve (H) to the liquid container (A) is No. 6 (3/8). This is the filler line (see below). 2. The line from the build-up and vent valve (F) to the overboard drain is No. 8 (1/2). This is the vent drain line. 3. The size and length of the evaporating coil tubing (J) depends upon the size and type of converter assembly (B) that is being used.



A. CONTAINER
B. CONVERTER ASSEMBLY
C. PRESSURE-CLOSING VALVE
D. 110-PSI OR 395-PSI RELIEF VALVE
E. CONTENTS GAGE
F. BUILDUP AND VENT VALVE
G. OXYGEN REGULATOR
H. FILLER VALVE
I. CHECK VALVE
J. EVAPORATING COIL
K. 90-PSI OR 345-PSI RELIEF VALVE

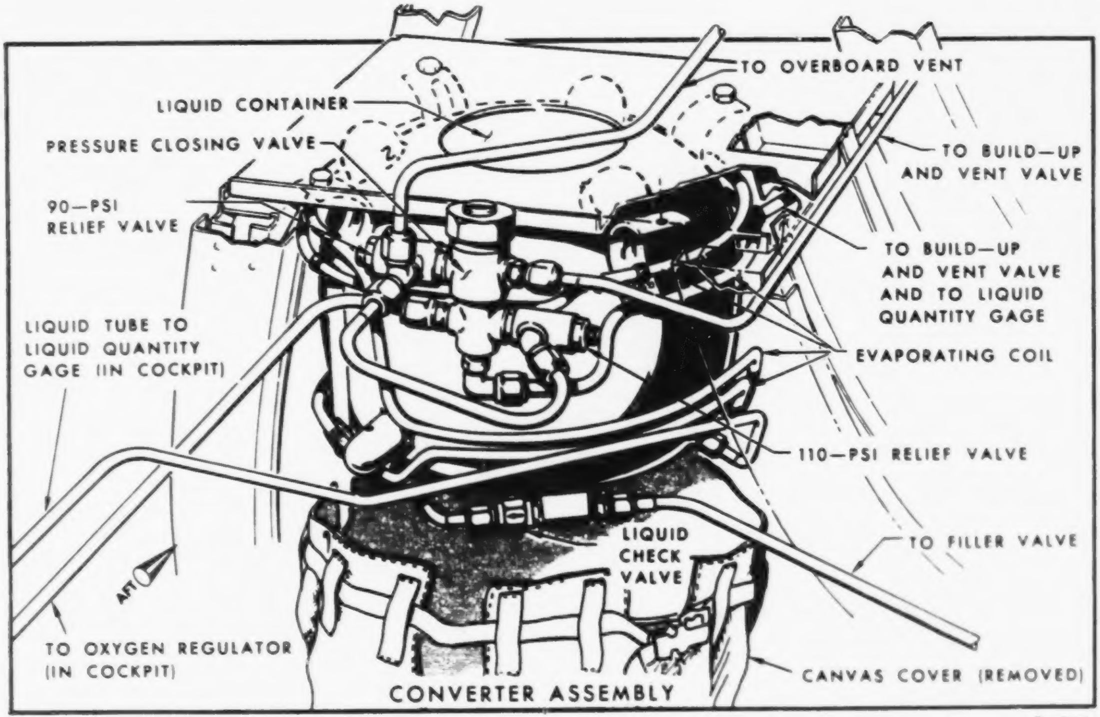
Check the following statements that are true.

____1. The filler valve is connected to the container with No. 6 tubing.
____2. Aluminum tubing is used in the liquid oxygen system.
____3. The vent drain line is No. 8 tubing.
____4. Most of the liquid oxygen tubing is No. 5.
____5. The evaporating coil is always No. 5 tubing.

Answers to Frame 12. 1. ✓ 2. ✓ 3. ✓ 4. ✓ 5. ____

Frame 13

Shown below is a typical converter assembly installation. This assembly has the same single function valves we have been discussing. Keep in mind the build-up and vent valve and filler valve are not shown because in this system they are not part of the converter assembly.


TO OVERBOARD VENT
LIQUID CONTAINER
PRESSURE CLOSING VALVE
2.
TO BUILD-UP AND VENT VALVE
90-PSI RELIEF VALVE
TO BUILD-UP AND VENT VALVE AND TO LIQUID QUANTITY GAGE
LIQUID TUBE TO LIQUID QUANTITY GAGE (IN COCKPIT)
EVAPORATING COIL
110-PSI RELIEF VALVE
TO FILLER VALVE
LIQUID CHECK VALVE
AFT
TO OXYGEN REGULATOR (IN COCKPIT)
CANVAS COVER (REMOVED)
CONVERTER ASSEMBLY

R-527

Review the illustration above and recall previously taught material to write in the components described in each statement.

1. This valve acts as the system pressure regulator. ____________________
2. This valve separates the liquid and gaseous phase of operation. _____
3. The liquid changes to a gas in this tubing. ____________________
4. This relief valve protects the build-up side of the system ______ psi.
5. This unit is vacuum insulated and holds the liquid. ________________
6. The servicing trailer hose is connected to this valve. ______________
7. This valve allows system pressure to build-up or be vented overboard. ____
8. This relief valve protects the evaporation side of the system ____ psi.
9. In the illustration, the pressure closing valve would be set at _____ psi.

Answers to Frame 13.
1. Pressure closing valve.
2. Liquid check valve.
3. Evaporation coil.
4. 90 psi.
5. Liquid container.
6. Filler valve.
7. Build-up & vent valve.
8. 110 psi
9. 70 psi

Frame 14

Refer to the illustration on the next page as you read the material in this frame. In the illustration, we show the flow of liquid and gaseous oxygen with bubbles and slashes in the lines while the system is being filled. Remember the build-up and vent valve has to be in "vent" to remove the filler valve dust cap. Note that with the build-up and vent valve in "vent," the top of the liquid container is vented overboard. Note also the pressure closing valve is "open" and the system contains no pressure. When the system is in "vent," the pressure closing valve is isolated from the top of the container. The pressure loss causes the bellows in the pressure closing valve to expand and open the valve. When the recharging trailer hose is connected to the filler valve, the operator allows 20 to 30 psi head pressure to build-up on top of the liquid in the recharging trailer. This pressure forces liquid into the converter container from the bottom. The container is full when a steady flow of liquid comes out the overboard vent.

Check the following statements that are true.

_____1. When the system is in "vent," the top of the container is vented overboard.

_____2. The pressure closing valve will open when pressure drops around the bellows.

_____3. The converter container is full when liquid comes out the overboard vent.

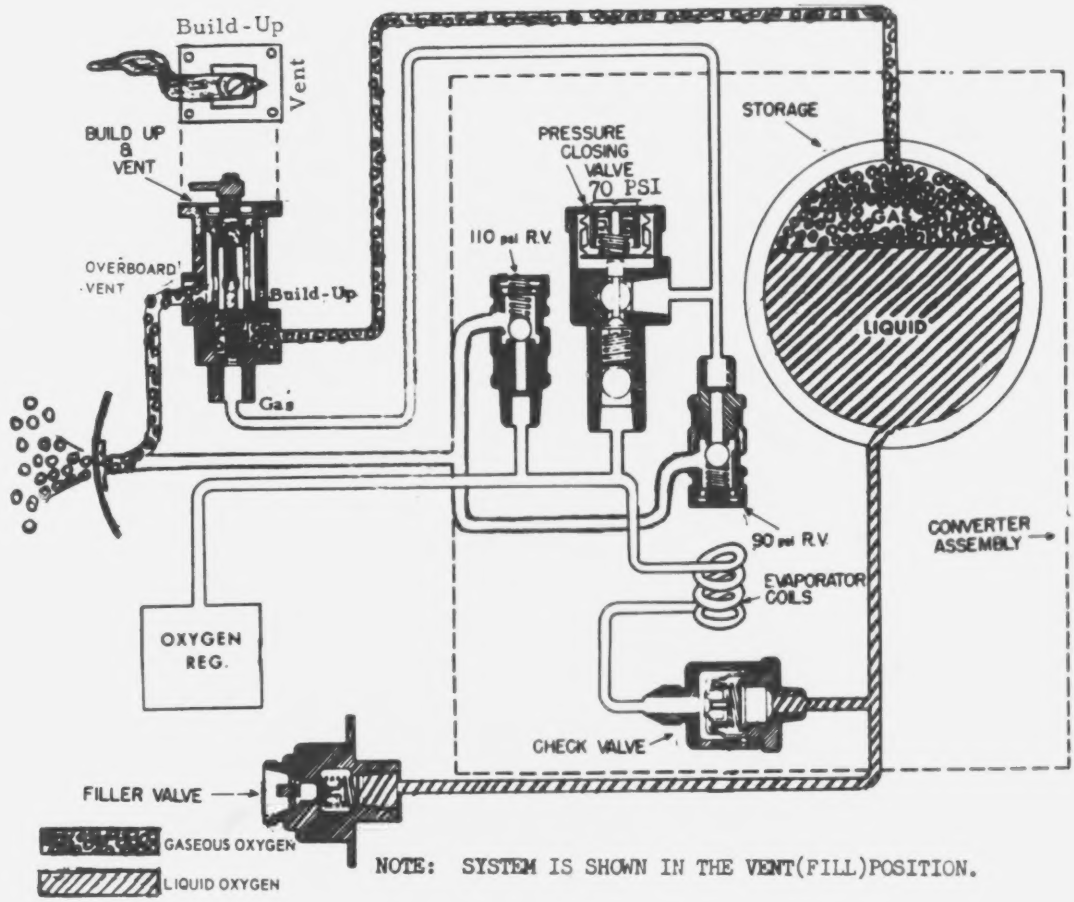
_____4. The system still contains 70 psi when placed in "vent."

_____5. Pressure in the recharging trailer forces liquid into the converter container.

_____6. When placed in "vent," any pressure in the system is vented overboard.

Answers to Frame 14. 1. ✓ 2. ✓ 3. ✓ 4. ____ 5. ✓ 6. ✓

Frame 15


Build-Up
Vent
BUILD UP & VENT
OVERBOARD VENT
Build-Up
Gas
PRESSURE CLOSING VALVE
70 PSI
110 psi R.V.
STORAGE
GAS
LIQUID
90 psi R.V.
EVAPORATOR COILS
CONVERTER ASSEMBLY
OXYGEN REG.
CHECK VALVE
FILLER VALVE
GASEOUS OXYGEN
LIQUID OXYGEN

NOTE: SYSTEM IS SHOWN IN THE VENT(FILL)POSITION.

No Response Required.

Frame 16

Refer to the illustration on the next page when you read the material in this frame. When the liquid container is full, the build-up and vent valve is moved back to the "build-up" position as shown in the illustration. With the system closed, pressure will now start to rise. If you recall, we said previously that the liquid check valve opens to let liquid into the evaporating coil and closes to prevent reverse flow. Also remember the pressure closing valve is _open_ until its bellows senses a 70 psi head pressure (in the low pressure system) on top of the liquid in the container. Note in the illustration that the pressure closing valve is again connected to the top of the container through the build-up and vent valve. Now, when the liquid changes to a gas in the evaporating coil, it goes up through the _open_ pressure closing valve and builds up head pressure on top of the liquid. When 70 psi is reached, the pressure closing valve _closes_. When this happens, the liquid left in the evaporating coil is still changing to a gas and building pressure in this side of the system. This pressure will soon close the liquid check valve (5 psi differential is required) and the system will stabilize. As gaseous oxygen is used through the regulator, a pressure drop allows the liquid check valve to open and more liquid enters the evaporating coil. As the liquid level decreases in the container, the head pressure _decreases_ also. This will cause the pressure closing valve to open again and allow the evaporation side to build up head pressure. There is little or no lag in maintaining the required head pressure; and for all practical purposes, oxygen is delivered to the regulator at a constant pressure of 70 or 300 psi depending upon the pressure closing valve setting.

Check the following statements that are _true_.

_____1. The bellows in the pressure closing valve senses the container head pressure.

_____2. In a 70 psi system, the pressure closing valve remains open until 70 psi is reached.

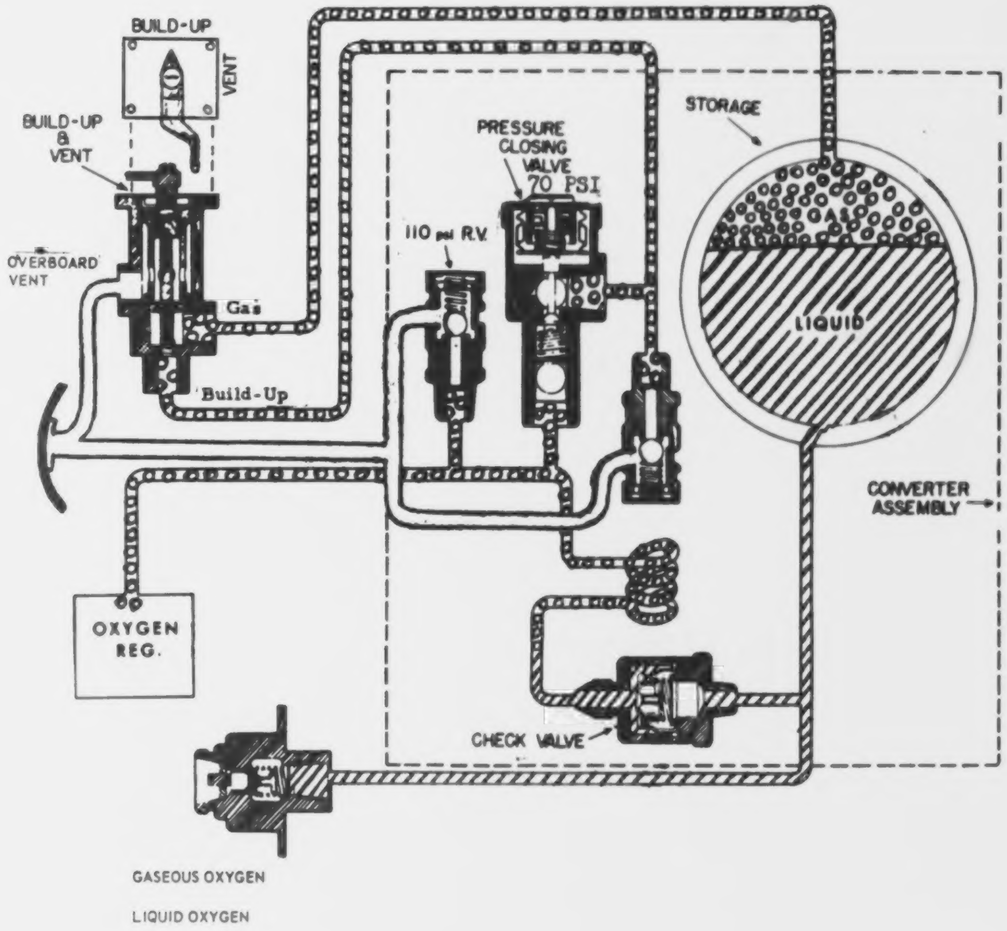
_____3. If excessive pressure builds up in the evaporator coils, the 90 psi R. V. will open.

_____4. The liquid check valve prevents reverse flow between the gaseous and liquid phase of the system.

_____5. When pressure in the evaporation side is lower than the head pressure on the container, the liquid check valve will open.

Answers to Frame 16. 1. ✓ 2. ✓ 3. ___ 4. ✓ 5. ✓

Frame 17


BUILD-UP
VENT
BUILD-UP & VENT
OVERBOARD VENT
Gas
Build-Up
PRESSURE CLOSING VALVE
70 PSI
110 psi R.V.
STORAGE
GAS
LIQUID
CONVERTER ASSEMBLY
OXYGEN REG.
CHECK VALVE
GASEOUS OXYGEN
LIQUID OXYGEN

No Response Required

Frame 18

Refer to the illustration on the next page when you read this material. In this illustration we have a separate build-up coil in our basic oxygen system. This is a short coil of tubing that changes the liquid to a gas for the sole purpose of maintaining a head pressure on top of the liquid in the container. Note that this coil of tubing runs directly from the bottom of the container to the bottom of the pressure closing valve. When a separate buildup coil is used, the evaporator coil no longer has to supply gaseous oxygen for a head pressure and more oxygen is available at the oxygen regulator for breathing. This additional circuit in no way affects the operation of the pressure closing valve. The bellows in top of the pressure closing valve still senses the head pressure through the build-up and vent valve. If the head pressure drops below 70 psi (or 300 in the high-pressure system), the pressure closing valve bellows and expands and unseats the valve. The buildup coil will not rebuild the head pressure. The build-up coil is usually around the liquid container and becomes part of the converter assembly.

Check the following statements that are true.

_____1. The build-up coil provides gaseous oxygen for maintaining a head pressure.

_____2. The build-up coil provides gaseous oxygen for the oxygen regulator.

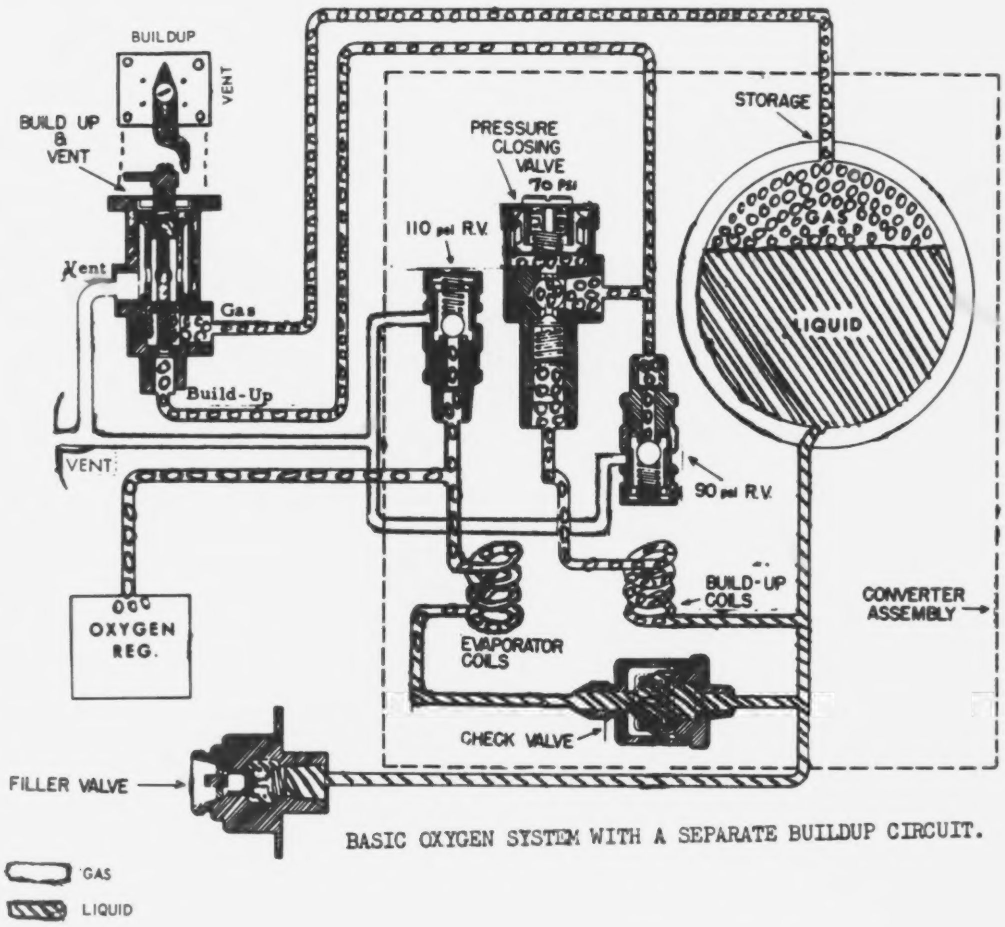
_____3. The build-up coil is part of the converter assembly.

_____4. When a build-up coil is used, the evaporator coils supply gaseous oxygen for breathing purposes only.

_____5. The pressure closing valve operates the same way when a build-up coil is used.

Answers to Frame 18. 1. ✓ 2. ___ 3. ✓ 4. ✓ 5. ✓

Frame 19


BUILDUP
VENT
BUILD UP & VENT
Vent
Gas
Build-Up
VENT
OXYGEN REG.
PRESSURE CLOSING VALVE 70 PSI
110 psi R.V.
STORAGE
GAS
LIQUID
90 psi R.V.
BUILD-UP COILS
EVAPORATOR COILS
CONVERTER ASSEMBLY
CHECK VALVE
FILLER VALVE
GAS
LIQUID

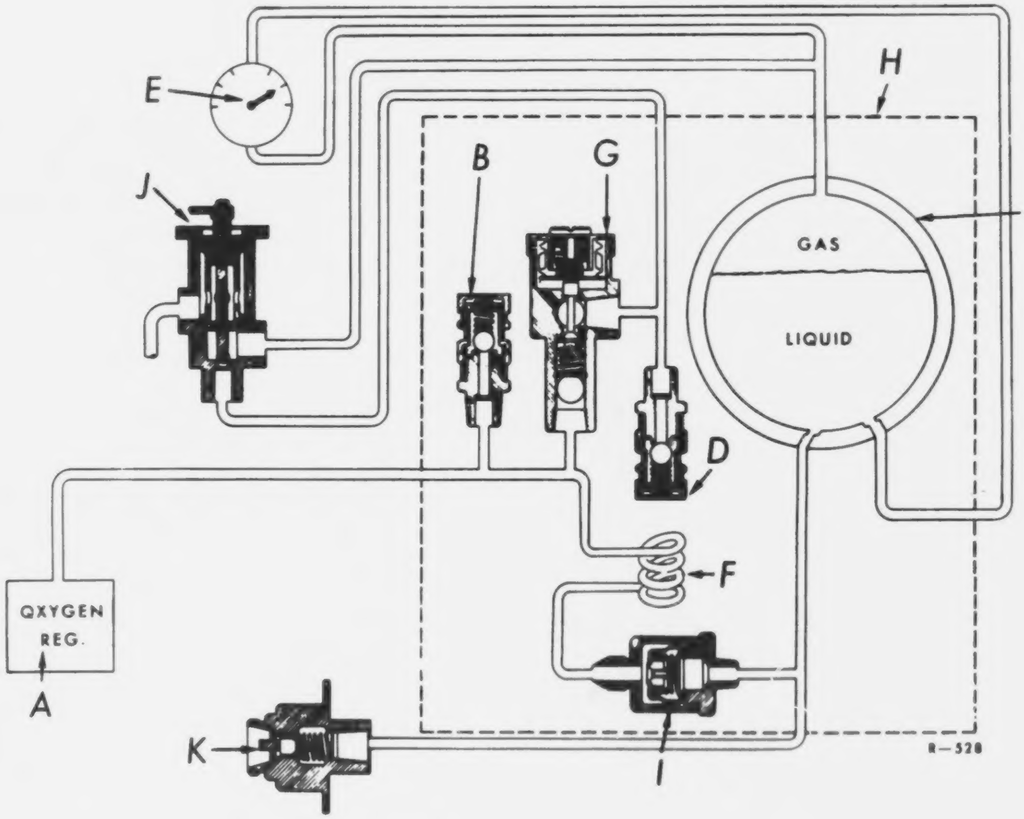
BASIC OXYGEN SYSTEM WITH A SEPARATE BUILDUP CIRCUIT.

No Response Required

Frame 20

INSTRUCTIONS

Identify the units in the oxygen system by matching the letters with the unit's name below.



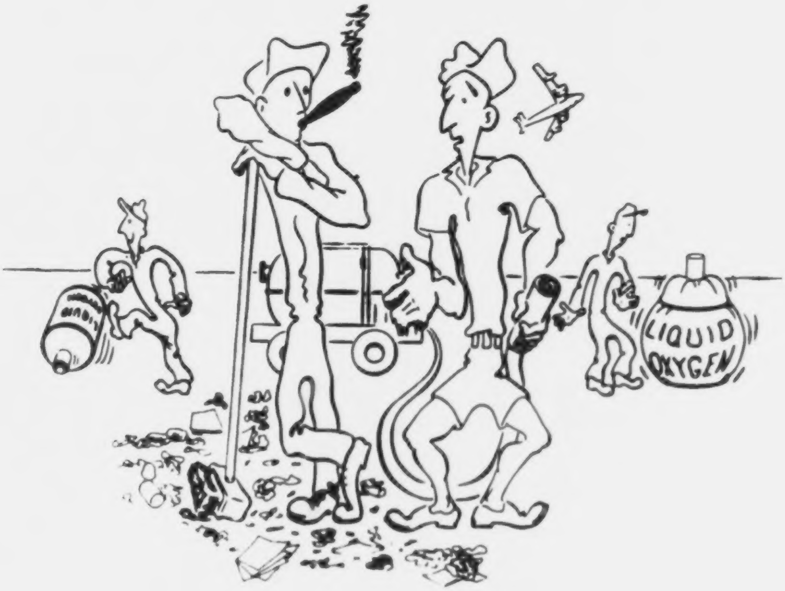
1. _____ liquid container.
2. _____ converter assembly.
3. _____ pressure closing valve.
4. _____ 110 or 395 psi relief valve.
5. _____ contents gage.
6. _____ build-up and vent valve.
7. _____ oxygen regulator.
8. _____ oxygen filler valve.
9. _____ liquid check valve.
10. _____ evaporator coils.
11. _____ 90 or 3[illegible]5 psi relief valve.

Answers to Frame 20

1. C
2. H
3. G
4. B
5. E
6. J
7. A
8. K
9. I
10. F
11. D

Frame 21

This completes our discussion on the basic liquid oxygen system. If you have any questions about the operation or components in this system, let your instructor know.



Remember Your Liquid Oxygen Safety.

PROGRAMMED TEXT
3ABR42331-PT-403

Technical Training

Aircraft Environmental Systems Mechanic

TTU-162/E LOX CONVERTER TESTER

9 January 1981

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: 9.9

OBJECTIVE

After completing this text, you will be able to relate 8 out of 10 components of the TTU-162/E tester to their purpose.

INSTRUCTIONS

This programmed text consists of 7 frames. Please read the information presented in each frame, think about it, and then write your answer. Check your answer on the next page following each frame. If you were wrong, read the frame again to see what caused you to miss the question. After you are sure of the information, move on to the next frame.

Note: When you are in the Oxygen Lab you will be required to operate this tester, so read these frames carefully and do not hurry.

Supersedes ST 3ABR42331-PT-403, 10 March 1980.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 1000; TTVSA - 1

Frame 1

The TTU-162/E Liquid Oxygen Converter Tester is used to completely bench check the individual components of ALL LOX converters. The tester will check for unsatisfactory components and give provisions for adjustments when necessary. You must refer to the individual converter technical order for the specific converter you are testing in order to do the checkout properly.

The tester consists of 2 pressure gauges, 3 flowmeters, 3 hand wheel valves, a thermometer, and 4 connection ports with associated lines and adapters in the lid of the tester. It is also required that you have a minimum of 80 feet of aluminum tubing to act as a buildup coil for the test setup. While you are reading this text, refer to figures 1 and 2 so that you can become familiar with the tester and its setup.

Answer the following True or False:

_____ 1. The TTU-162/E can be used to completely bench check all liquid oxygen converters in the US Air Force inventory.

_____ 2. In order to operate this tester, 80 feet of aluminum tubing must be used to simulate the aircraft's buildup coil.

PROCEED TO FRAME 2

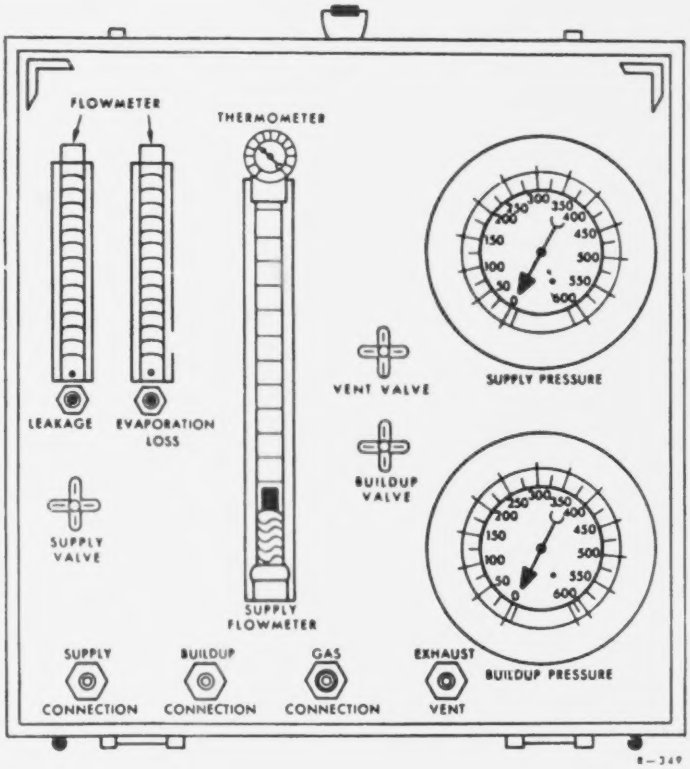

FLOWMETER
THERMOMETER
0
50
100
150
200
250
300
350
400
450
500
550
600
SUPPLY PRESSURE
VENT VALVE
LEAKAGE
EVAPORATION LOSS
BUILDUP VALVE
SUPPLY VALVE
0
50
100
150
200
250
300
350
400
450
500
550
600
SUPPLY FLOWMETER
SUPPLY CONNECTION
BUILDUP CONNECTION
GAS CONNECTION
EXHAUST VENT
BUILDUP PRESSURE

Figure 1. TTU-162/E Lox Converter Tester.

CORRECT RESPONSES TO FRAME 1: 1. True 2. True

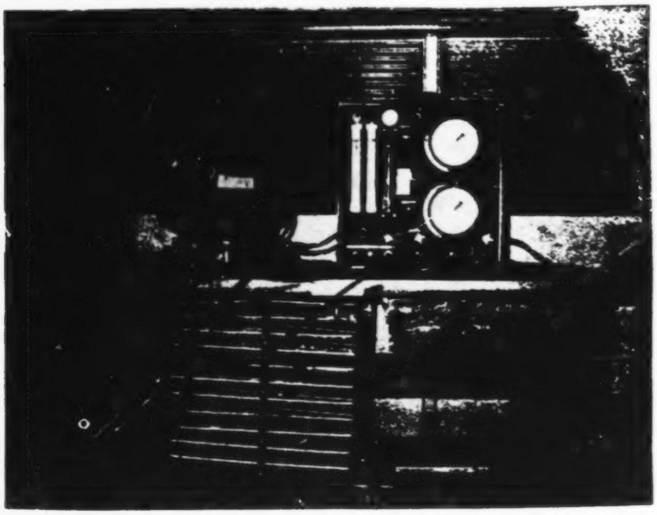


Figure 2. TTU-162/E Test Set-up (Typical).

Frame 2

Prior to testing the converter, it must be filled with liquid oxygen by using a servicing cart. After filling, the converter must set for at least 15 minutes to allow the liquid to stabilize. When the converter is stabilized, you will begin with the first test and continue through the technical order to the last test. Each converter will be tested for evaporation loss, pressure buildup time, delivery flow rate, relief valve(s) pressure setting(s), and internal leakage through relief valve(s). We will next take an in-depth look at the individual components of the TTU-162/E tester.

Answer the following True or False:

_____ 1. After servicing the converter under test with LOX, it must stabilize for a minimum of 5 minutes.

_____ 2. The converter will be tested for evaporation loss, pressure buildup, flow rate and relief valve operation.

PROCEED TO FRAME 3

CORRECT RESPONSES TO FRAME 2: 1. False 2. True

Frame 3

There are 2 pressure gauges on the tester. They are used to monitor supply pressure and buildup pressure. These are on the right side of the TTU-162/E and are labeled as to which pressure they read. The supply pressure is that pressure which is on the liquid oxygen while it is being delivered to the regulator(s). The buildup pressure is that pressure which is on the liquid as it is stored in the converter. Both gauges must be capable of reading from 0 to 600 psig.

Answer the following True or False:

_____ 1. The pressure gauges on the TTU-162/E monitor the relief valve and supply pressures.

_____ 2. Both pressure gauges should be capable of reading pressures in excess of 600 psi.

PROCEED TO FRAME 4

Frame 4

The large flowmeter located in the center of the tester is used to monitor the amount of oxygen flowing through the tester and into the regulator(s). It is called the Supply Flowmeter, and it is incremented in LPM (liters per minute). The reading must be taken from the TOP of the float in the tube to be accurate. This float is set by opening and closing the supply valve on the tester. The technical order for the converter under test will tell you exactly where to stabilize the top of the float. Immediately above this supply flowmeter is a thermometer. The purpose of this thermometer is to indicate the temperature of the oxygen after it leaves the supply flowmeter and before it is delivered to the oxygen regulator(s). Any significant drop in the temperature of the oxygen during any of the tests should be checked and corrected before proceeding, or damage to the tester will result from liquid reaching the flowmeter.

Fill in the missing words:

1. The large flowmeter is in the _________ of the TTU-162/E and monitors ________ of _________ flowing through the tester.

2. All readings on the ________ flowmeter will be taken from the _____ of the ________ in the tube to be precise.

3. Any significant __________ in _____________ of the oxygen going through to the flowmeter should be investigated.

PROCEED TO FRAME 5

CORRECT RESPONSES TO FRAME 3: 1. False 2. False

CORRECT RESPONSES TO FRAME 4: 1. center, amount, oxygen 2. supply, top, float 3. decrease, temperature

Frame 5

There are two smaller flowmeters in the upper left corner of the tester with inlet ports at the bottom of each. These flowmeters are used to check the amount of internal leakage through the relief valve (the leakage flowmeter) and the vacuum space of the converter (evaporation loss flowmeter). The inlet ports at the bottom of each flowmeter are used to hook up a rubber or a silicone hose to facilitate the checks. Similar to the larger supply flowmeter, these flowmeters are incremented in liters per minute. The major difference between the supply flowmeter and the two smaller ones is that the smaller ones are incremented at a much lower scale.

Answer the following True or False.

_____ 1. The two smaller flowmeters on the TTU-162/E are used to check for evaporation loss and relief valve internal leakage.

_____ 2. These two flowmeters (similar to the supply flowmeter) are incremented in LPM (liters per minute).

PROCEED TO FRAME 6

Frame 6

The three valves on the tester control panel are the supply valve, the buildup valve, and the vent valve. Though their actual position on the tester panel will change, their purpose will be the same. The vent valve is used to vent the head pressure from the test setup when it is no longer required. The supply valve is used to adjust the rate of flow of the oxygen going across the supply flowmeter and into the regulator(s). Remember that this is the reading that is taken from the top of the float. The buildup valve, when opened, allows the converter under test to reach its operating pressure. The technical order will tell you which valve to open and/or close as you proceed through the checkout.

Fill in the missing words:

1. The three valves on the converter tester are the ________ valve, the __________ valve and the _______ valve.

2. The valve which is used to adjust for proper rate of flow through the tester is the _________ valve.

PROCEED TO FRAME 7

1314

CORRECT RESPONSES TO FRAME 5: 1. True 2. True

CORRECT RESPONSES TO FRAME 6: 1. supply, buildup, vent 2. supply

Frame 7

Located at the very bottom of the tester are four connection ports. These are the supply, buildup, gas and exhaust vent ports. These ports are used together with the lines, hoses, adapters and fittings inside the lid of the tester. Proper use of these items will enable you to check all converters in the US Air Force inventory.

We cannot go into any great detail of the actual hookup procedures since these will vary greatly with the converter and tester being used. The important thing to remember here is to follow the proper technical order for the converter that you are checking.

Answer the following True or False.

_____ 1. There are six connection ports at the bottom of the TTU-162/E tester.

_____ 2. Actual hookup procedures are the same for all converters and testers.

PROCEED TO MATCHING EXERCISE

CORRECT RESPONSES TO FRAME 7: 1. False 2. False

MATCHING EXERCISE

INSTRUCTIONS

Match the components of the TTU-162/E Converter Tester in the left column with their correct purpose in the right hand column.

_____ 1. Supply Flowmeter

_____ 2. Buildup Valve

_____ 3. Leakage Flowmeter

_____ 4. Vent Valve

_____ 5. Connection Ports

_____ 6. Supply Valve

_____ 7. Evaporation Loss Flowmeter

_____ 8. Thermometer

_____ 9. Supply Pressure Gauge

_____10. Buildup Pressure Gauge

a. shows if the oxygen is too cold going to the regulator(s).

b. shows oxygen pressure while stored in the converter.

c. tells if the relief valve is leaking internally.

d. indicates if the converter is allowing too much evaporation.

e. shows the amount of liquid being delivered to the regulators.

f. allows a means of connecting the tester to all types of converters.

g. shows oxygen pressure while it is being delivered to the regulator.

h. is used to set the float in the larger flowmeter.

i. allows the converter to reach operating pressure.

j. relieves oxygen head pressure when no longer required.

k. uses spring tension to set the smaller flowmeters.

Now check your responses with the following key.

If you had an incorrect response, go back and review the appropriate frame.

CORRECT RESPONSES TO MATCHING EXERCISE: e 1. i 2. c 3. j 4. f 5.
h 6. d 7. a 8. g 9. b 10.

WORKBOOK

C3ABR42331-WB-403

Technical Training

Aircraft Environmental systems Mechanic

LIQUID OXYGEN SYSTEM LABORATORY PROJECTS

29 MAY 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE ONLY

DO NOT USE ON THE JOB

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-WB-403

LIQUID OXYGEN SYSTEM LABORATORY PROJECTS

OBJECTIVES

1. Using a trainer, safety equipment and workbook, perform an operational check of a liquid oxygen system. A maximum of one instructor assist is allowed. Apply safety precautions without error.

2. Given a trainer, applicable technical technical orders and workbook, use a sonic leak detector to leak check a liquid oxygen system. A maximum of one instructor assist is allowed. Apply safety precautions without error.

3. Using the necessary tools, equipment, applicable TOs and workbook, repair selected components of a liquid oxygen system. A maximum of one instructor assist, per component, is allowed. Apply safety precautions without error.

4. Given applicable TOs and workbook, use a TTU/162E converter tester to bench check a liquid oxygen converter. A maximum of one instructor assist is allowed. Apply safety precautions without error.

5. Given applicable TOs and workbook, use a regulator tester to perform an operational check of an oxygen regulator. A maximum of one instructor assist is allowed. Apply safety precautions without error.

6. Given a trainer, applicable TOs and workbook, use a quantity indicator capacitance tester and bench check the converter capacitance system. A maximum of one instructor assist is allowed. Apply safety precautions without error.

INFORMATION

If you cannot find the equipment that is used with a project, call an instructor. Any test equipment that you use WILL be put back in the same manner that you found it.

Safety is one of the most important things that the instructor will check you on while you are in the LOX lab. Do not take any chances with liquid nitrogen or with the electrical equipment. WORK SAFELY!

Supersedes C3ABR42331-WB-403, 13 September 1983.
OPR: 3370 TCHTC
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Read all instructions carefully. If in doubt, ask your instructor for help. Your instructor will move you to the work area for each project. You will use the list of equipment as directed by the various projects. Each project has a list of specific procedures.

> Note: Procedures that have an asterisk (*) in front of them are considered to be the hardest tasks. Instructor assists may be given on them as stated in the objectives.

SPECIAL SAFETY PRECAUTIONS

There will be no danger with any of the projects if you follow instructions. An instructor will be available at all times to help you.

Due to the special hazards of a training environment, you will work with liquid nitrogen. You must locate and observe all safety points that must be followed when handling liquid oxygen. To help you, we have made a list of the safety points. Remember, that in the field you will be working with liquid oxygen instead of liquid nitrogen, so you must be alert and safety conscious at all times and treat nitrogen as if it were liquid oxygen.

1. Hazards of handling liquid and gaseous oxygen.

    a. Liquid oxygen, in contact with the skin, will cause severe frostbite and burns.

    b. When liquid oxygen is mixed with fuels it will cause a dangerous explosive hazard.

    c. Frozen fuel/liquid oxygen mixtures are "shock sensitive."

    d. When gaseous oxygen is absorbed in clothing, it will stay there for some time.

2. First Aid Procedures

    a. If liquid oxygen gets into the eyes, immediately flood the eyes with water. (See instructor for water location.)

    b. If liquid oxygen gets on the bare skin, thaw the area by flooding with water.

    c. Get medical attention immediately if liquid oxygen gets on the skin or in the eyes.

3. Safety Precautions

    a. Remove all your jewelry NOW.

b. There will be NO SMOKING in the LOX at any time.

c. Personnel must wear the proper face shield, apron and gloves when handling liquid oxygen. This equipment is provided in the lab for you to use.

d. You must be familiar with the sections in TO 15X-1-1 that give points on oxygen safety. Ask your instructor for the page and paragraph numbers.

Project 1. OPERATIONAL CHECK OF A LIQUID OXYGEN SYSTEM

In this part of the lab, you will be using a liquid oxygen system trainer. This trainer is a mock-up of an F-4 aircraft. All the oxygen system components that you see on this trainer are on the F-4 aircraft. You will be performing an operational check of a liquid oxygen system on this trainer.

To perform this operational check, you will need a serviced converter. The instructor will service the converter for you. After the instructor has serviced the converter, you must wait 15 minutes or until all frost on the converter lines is gone before you can check the system.

QUANTITY INDICATING SYSTEM

1. The first step in operationally checking the liquid oxygen system is to insure that the quantity gages are operating properly. At this point, look at the liquid oxygen quantity gages (indicators) located on the right side of the trainer in front of you. The upper indicator is called the master quantity indicator. This indicator is mounted in the rear cockpit of the aircraft. The master quantity indicator gets its reading directly from the converter through the coaxial and shielded cables. Look at the reading on the master quantity indicator. The reading is ______ liters.

2. Now we will look at the repeater quantity indicator (lower gage). The repeater indicator does just what its name implies, it repeats the reading from the master quantity indicator. The repeater quantity indicator is located in the front cockpit in the aircraft. The reading from the repeater indicator is _______ liters.

*3. Another part of the quantity indicating system is the PRESS TO TEST switch located to the upper left of the master quantity indicator. The purpose of this switch is to manually check the low quantity portion of the system. If, at any time, the liquid in the converter drops to 10% of the converter capacity, a quantity low light will come on to tell the crew that there is low liquid oxygen level. The PRESS TO TEST switch manually checks this portion of the system. Pressing the PRESS TO TEST switch causes the indicator to rotate counterclockwise. When the needle reaches the 10% mark, the low light should come on. For a 10 liter converter, 10% is 1 liter. At this time, operate the PRESS TO TEST switch. When the low light comes on, record the reading ________ liters.

See your instructor at this time to check your work.

Instructor's Initials __________

SYSTEM OPERATION

4. Now that you have the quantity of liquid in the converter, it is necessary to insure that the oxygen pressure in the system is between 70 to 110 ± 10 psi. What is your reading on the oxygen regulator pressure gages? _____ _____ psi. If your readings are incorrect, tell your instructor before continuing.

Instructor's Initials __________

Note: If at any time, the system pressure becomes too high, the pressure relief valve will relieve pressure. This valve will not open until system pressure reaches 130 psi. When it opens, it vents the excessive pressure through the overboard vent port.

*5. Find the diluter switch on one of oxygen regulators and place it in the Normal position. Place the ON-OFF switch to the ON position. Place the EMERGENCY switch to the EMERGENCY position. Check to make sure that flow is coming out of the mask to the regulator flex hose. Is oxygen coming out of the hose? ______. Turn off the regulator. Now, check the other regulator the same way. Does this regulator have flow coming out of it? ______. Pressure on the regulator gage will drop down during flow of the regulators. When the regulators are not in use, system pressure will build back up.

Have instructors check your work at this time.

Instructor Assists

Instructor's Initials __________

Project 2. LOCATING OXYGEN SYSTEM LEAKS

Your have learned in the last project how to check if you have liquid in the converter, through the use of quantity indicators. You also learned how to check if the system is operating. In order for the system to work properly, you must have the correct pressure in the system. This project deals with locating leaks in the system which could cause an incorrect pressure in the system.

Locate the oxygen regulators on the trainer. On the oxygen regulators, you will see a pressure gage. The pressure on the gage should be 70 to 110 ± 10 psi.

Note: The oxygen system you are using is a low pressure system. Check the pressure reading from the oxygen regulator at this time. The

pressure reading is ______ PSI. If your pressure reading is incorrect, tell your instructor at this time.

Instructor's Initials ___________

Now that you have insured that there is pressure in the system, you can perform a leak check. Go to locker #1 and obtain an ultrasonic leak detector.

The ultrasonic leak detector is also known as an ultrasonic translator. It is a completely transistorized, battery operated instrument that detects sounds within the ultrasonic frequency range and converts them into sound that can be heard by the human ear. Audible (hearable) sounds within the normal hearing range, are not picked up by this instrument. Other than normal background hiss, the only sounds that are heard from the loudspeaker are ultrasonic sounds that have been converted to audible sounds. The unit is portable and has a shoulder carrying strap. The major components are two probes, a lead assembly for attaching the probes to the detector, a rubber adapter that reduces the area of coverage of the probe, and a headset. The headset provides a means of listening, when plugged in, by cutting out the loudspeaker. On the front panel of the unit are three plug-in jacks, a volume control, an ON-OFF toggle switch and a meter. The meter measures the level of sound output in decibels.

1. Open the case of the ultrasonic leak detector.

2. Take the probe assembly from the top of the carrying case and the lead assembly from inside the cover of the case.

*3. Plug the lead into the probe assembly.

4. Plug the other end of the lead into the jack marked PROBE.

5. Place the switch on the tester to the ON position.

6. Turn the volume control to the right to turn up the volume.

7. Blow into the probe to check for sound output. Readjust the volume control if necessary.

*8. Slowly move the probe over the tubing and fittings on the trainer. A leak will cause the unit to make a sound. As the probe is moved closer to a leak, the sound will get louder.

9. If you find a leak, have your instructor check your work.

10. Turn the tester switch to the OFF position.

11. Put the lead assembly back into the carrying case cover. Put the probe on the case.

*Taping fittings.

Instructor Assists

Instructor's Initials ___________

Project 3. REPAIRING OXYGEN SYSTEM COMPONENTS

As you have already learned, there are many problems that you may encounter with the liquid oxygen system. After you complete your troubleshooting to find out what or where the malfunction is, you have to repair the faulty components.

During this project you will be simulating malfunctions of converters, and taking the appropriate action. This could be removing, replacing or repairing a component or any combination of the three. Just as quality control personnel in the field will evaluate and check your work for safety and proper procedures, so will your instructor. Inspecting and checking work insures that all personnel are accomplishing the work accurately and safely.

Instructor Assists

See your instructor at this time.

Instructor's Initials ___________

Project 4. TTU/162F CONVERTER TESTER

Note: Use proper safety gear for LOX which is located in locker #2.

1. TEST NUMBER 1 - The vacuum space of the liquid oxygen converter under test needs to be checked for the loss of vacuum. A loss of vacuum will cause a high evaporation rate of the liquid.

a. Check to see that the vent valve is still OPEN (counterclockwise).

b. Take the metal flex hose from the exhaust vent of the tester and place it on the bench.

c. Connect one end of the rubber hose to the exhaust vent and the loose end of the hose to the EVAPORATION LOSS FLOWMETER of the tester.

d. Watch the ball in the flowmeter. If the ball rises from zero (0), the amount of leakage is as shown on the markings of the glass tube.

The leakage is ________ liters per minute.

e. Use the information in table 1 to choose the leakage that is allowed for the converter under test.

MAXIMUM LOSS SHALL NOT EXCEED	
Converter Size (Liters)	Allowable Leakage (Liters Per Minute)
5	0.60
8	0.69
10	0.75
20	0.92
25	1.0
75	2.1

Table 1. Allowable Converter Leakage.

f. Compare the leakage listed in step d with the leakage allowed for the converter under test. (10 Liter). The converter vacuum is

(good/bad) ___________.

g. Take the hose from the flowmeter and exhaust vent and place the hose on the bench. Reconnect metal flex hose to exhaust vent.

Instructor's Initials ____________

2. TEST NUMBER 2 - This test is made to find out how much time it takes the converter under test to build up to operating pressure. Operation of the pressure closing valve will also be checked.

a. Close the vent valve on the tester.

b. Open the build-up valve.

c. Maximum build-up time to operating pressure (70 or 300 psi) is 10 minutes. Record start time ________.

d. Watch the build-up and supply pressure gages. Both gages should rise at about the same rate.

e. At the end of ten minutes look at the build-up gage. The pressure should be either 70 or 300 psi. Record the pressure. ________ psi.

Note: If the converter does not reach operating pressure in 10 minutes, the pressure setting is out of tolerance (above or below 70 or 300 psi), the pressure closing valve must be adjusted or replaced.

f. The pressure closing valve is good/bad ________.

CONVERTER	SPECIFICATION	NO. OF RELIEF VALVES	OP PRESS (PSI)	SIZE (L)	DESIGN FLOW (L/M)
A-2	MIL-C-6650	2	300	8	80
A-3	MIL-C-7407	2 (INDIVIDUAL)	70	5	20
MA-1	MIL-C-25021	2	300	20	120
ME-3	MIL-C-25674	2	300	25	150
GCU-2/A	MIL-C-25777	1	70	10	72
GCU-3/A	MIL-C-25781	1	70	10	72
GCU-10/A	MIL-C-25974	2 (INDIVIDUAL)	300	10	80
GCU-11/A	MIL-C-25972	2	300	10	100
GCU-12/A	MIL-C-25973	1	70	5	72
GCU-14/A	MIL-C-26358	1	70	5	72
GCU-17/A	MIL-C-27336	2	300	25	150
*GCU-20/A	MIL-C-27652	2	300	75	400

Table 2. Converter Data.

3. TEST NUMBER 3 - The converter test will be checked for maximum and minimum pressures and flow rates. Liquid oxygen converters are made to give a set amount of gaseous oxygen per minute. The amount will change with the type of converter. During this test, the liquid oxygen that flows into the evaporator coils is changed to a gas that flows overboard through the supply flowmeter.

a. List the temperature that is shown on the temperature gage at the top of the supply flowmeter on the tester. The temperature is

__________.

b. For the converter under test, find the design flow rate in table 2.

c. Watch the float in the supply flowmeter.

*d. After the supply valve is opened, stabilize the top of the float at the design flow rate for the converter under test. This is done by opening and closing the supply valve and checking table 2.

e. Let oxygen flow for 15 minutes to allow liquid to flow into the coils under the trainer.....during the 15 minutes, read steps f through j.

f. Watch the build-up pressure gage. This is showing converter head pressure. The pressure closing valve maintains head pressure in the converter at 70 ± 2 psi. This pressure on the build-up gage should not drop during the flow of the converter.

g. If the pressure on the build-up gage drops, the pressure closing valve is bad.

h. What is the converters head pressure now? _______psi. Is the pressure closing valve good or bad? __________.

i. If at this time your 15 minutes flow time is up, continue to next step. If you still have time to wait "WAIT UNTIL THE END OF THE 15 MINUTES," then proceed with the next step (j).

*j. Watch your supply gage. At the same time, close the supply valve and monitor the pressure increase on the supply gage. At what PSI did the indicator rise too? _________psi. This is checking to see at what pressure your container relief valve opens. The indicator will rise until it reaches the relief valve setting and then it will drop as the valve starts to close.

k. Check the temperature gage. The temperature should be about the same as for step a.

Instructor's Initials ____________

4. TEST NUMBER 4.

a. Put the rubber hose on the exhaust vent of the tester.

b. Place the other end of the hose on the leakage flowmeter.

c. If the ball in the flowmeter does rise from the zero mark, list the amount of leakage shown. The leakage is _______ LPM.

Number of Relief Valves Installed	Leakage Permitted
1	0.01 LPM
2	0.02 LPM

Table 3. Permitted Relief Valve Leakage.

d. From table 3, find the amount of permissible leakage. Compare this setting with the leakage listed in step c. This check is to find out if the relief valve has now completely closed after the high pressure has been released. The reseating of the relief valve is

(good/bad) __________.

e. Take the hose from the flowmeter and converter vent and place the hose on the bench.

f. Reconnect the metal flex hose to the exhaust vent.

g. Close the build-up valve on the tester.

h. Open the vent valve in order to vent converter head pressure.

i. Open the supply valve and bleed off the supply pressure.

j. Close the supply valve.

Note: At this time you would have a serviceable converter or one on which work would have to be done to make it serviceable.

Instructor Assists

Instructor's Initials ___________

Project 5. OXYGEN REGULATOR FIELD TESTER

1. Obtain TO 33D2-10-55-1, an oxygen regulator field tester and a trainer from the instructor.

2. Turn to page 1-1 in the TO and read paragraphs 1-8 and 1-9.

3. Turn to page 2-1 and, using the TO and the directions on the lid to perform the tests, proceed with the first test in the workbook.

4. Perform the following tests using the TO and directions on the lid of the field tester. Place your readings for each test in the correct place below. Circle either pass or fail, depending on whether the regulator passed or failed the test.

a. OUTWARD LEAKAGE TEST (para 4-5 in TO), (test #6 on tester lid)

Readings ________________________________ PASS FAIL

b. MAXIMUM FLOW TEST (para 4-6 in TO), (test #1 on tester lid)

Readings ________________________________ PASS FAIL

*c. AIR CHECK VALVE PRESSURE DROP TEST (para 4-7 in TO), (Test #2 on tester lid)

Readings ________________________________ PASS FAIL

d. SUCTION FLOW TEST (para 4-8 in TO), (test #3 on tester lid)

Readings ________________________________ PASS FAIL

e. AIR RATIO SHUTOFF TEST (para 4-9 in TO), (test #4 on tester lid)

Readings ________________________________ PASS FAIL

f. PRESSURE BREATHING TEST (para 4-10 in TO), (test #5 on tester lid)

Readings ________________________________ PASS FAIL

g. DEMAND VALVE LEAKAGE TEST (para 4-11 in TO), (test #7 on tester lid)

Readings ________________________________ PASS FAIL *h. BLINKER FLOW TEST (para 4-12 in TO), (test #8 on tester lid)

Readings ______________________________ PASS FAIL

i. MASK PRESSURE MEASURMENT (para 4-13 in TO), (test #9 on tester lid)

Readings ______________________________ PASS FAIL

Have your instructor check your work at this time.

Instructor Assists

Instructor's Initials __________

Project 6. TF-20-1 CAPACITANCE TYPE LIQUID QUANTITY SYSTEM TRAINER

1. The tester is already set up for you, there will be a checklist for you to follow at the end of the test to set up the tester for the next students.

2. The first test will be done on a 10 liter converter for practice to give you an idea how the tester works.

3. Place the power switch #1 to the ON position. The red light near the switch should come on.

4. Connect the shielded lead from point 11 to the HI-Z connector of the 10 liter converter under test.

5. Connect the coaxial lead from point 12 to the LO-Z-connector of the 10 liter converter.

*6. Set the capacitance RANGE SELECTOR #6 to the lowest range that will give a stable reading (the indicator does not rotate continuously) on capacitance indicator #7. If the inner needle does cross above 100, place the range selector to the next higher multiplier.

> Note: Study the capacitance meter dial (figure 1). With the capacitance range selector in the xl position, a reading of 43.25 MMF is obtained as shown in figure 1. The last decimal place is estimated by eye. In the x3 position this reading is 43.25 X 3 = 129.75 MMF. For the x10 and x50 positions the values are 432.50 MMF and 2162.50 MMF. Now apply what you have to read to interpret your reading on the converter you are checking. These readings are examples only.

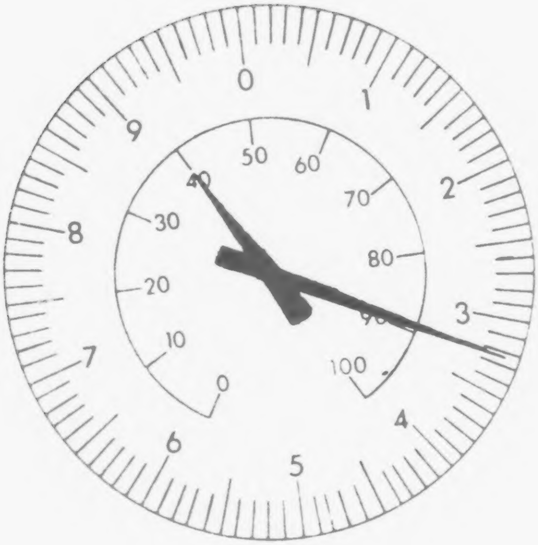


Figure 1. Capacitance Meter Dial.

7. Complete the statements. These statements will be done for the first converter under test ONLY.

a. The capacitance indicating reading is ______MMF and the range selector is in the x______ position.

b. The MMF reading multiplied by the range selector position is ______MMF.

CONVERTER SIZE	REQUIRED READING	YOUR READING
10 Liter	123.5 ± 1.0	
25 Liter	303.5 ± 2.5	
75 Liter	910.0 ± 7.5	

Table 4. Converter Size-Capacitance Relation.

c. Select the required reading from table 4 for the size converter you are testing. Place your reading in the appropriate space in the table.

d. The required reading is _______MMF and the number in step b (is/is not) _________ in the tolerance of the required reading. The converter capacitance probe is (good/bad) _________.

e. Now check the capacitance of the 10, 25, and 75 liter converters. Put your readings in the space provided in table 4.

f. Have instructor check your readings.

Instructor Assists

Instructor's Initials ___________

SERVICE TEST
WORKBOOK
C3ABR42331-WB-403

Technical Training

Aircraft Environmental Systems Mechanic

OXYGEN SYSTEMS LABORATORY PROJECTS

26 January 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

RGL: N/A

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Environmental Pneudraulic Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-WB-403

OXYGEN SYSTEMS OXYGEN LABORATORY PROJECTS

OBJECTIVES

a. Using a trainer, go-no-go gage, inspection workcard, AFTO Form 349, and work unit code manual, inspect the oxygen system recording a minimum of 12 discrepancies. One instructor assist per form is permissible. Apply safety precautions without error.

b. Using a field tester and oxygen regulator, perform an operational check of the oxygen regulator. One instructor assist is permissible. Apply safety precautions without error.

c. Using a trainer and leakage test equipment, perform an operational and leakage test on a liquid oxygen system with one instructor assist. Apply safety precautions without error.

d. Using a capacitance tester, trainer, oxygen converter and necessary tools, bench check the converter capacitance system with one instructor assist permissible. Apply safety precautions without error.

e. Using the TTU/162E tester, perform an operational check and troubleshoot a liquid oxygen converter for malfunction. One instructor assist is permissible. Apply safety precautions without error.

f. Using the necessary tools and equipment, remove, replace and repair selected components of an oxygen system. One instructor assist can be given for each component. Apply safety precautions without error.

EQUIPMENT

Oxygen System Trainer Number 3251
Go-No-Go Gage
Test Gage, TTU-28/E
Sonic Leak Detector
Liquid Oxygen System Tester, TF-20-1
Tester Type TTU-162/E
Hot Purge Kit Heating Assembly
Oxygen System Trainer Number 1762
Pressure Demand Regulator, D2-A
Demand Regulator
Oxygen Safety Equipment
Toolkit
Oxygen Converter
TF-20-1 Capacitance Tester
Cryotainer
Field Tester

INFORMATION

If you cannot find the equipment that is used with a project, call an instructor. Any test equipment used will be put back in the same manner that it was found.

One of the most important things the instructor will check you on is safety while you work in the oxygen laboratory. Do not take any chances with liquid nitrogen or with the electrical equipment. WORK SAFELY.

Read all instructions carefully. If in doubt, ask your instructor for help. Your instructor will move you to the work area for each project. You will use the list of equipment as directed by the various laboratory projects. Each project has a list of specific procedures.

SPECIAL SAFETY PRECAUTIONS

There will be no danger with any of the projects if you follow instructions. An instructor will be available at all times to help you.

Due to the special hazards of a training environment, you will work with liquid nitrogen. You must locate and observe all safety points that must be followed when handling liquid oxygen. To help you, we have made a list of the safety points. Remember that in the field you will be working with liquid oxygen instead of liquid nitrogen, so you must be alert and safety conscious at all times and treat the liquid nitrogen as if it were liquid oxygen.

1. Hazards of handling liquid and gaseous oxygen.

    a. Liquid oxygen in contact with the skin will cause frostbite and burns.

    b. When liquid oxygen is mixed with fuels it will cause a dangerous explosive hazard.

    c. Frozen fuel/liquid oxygen mixtures are "shock sensitive."

    d. When gaseous oxygen is absorbed in clothing it will stay for some time.

2. First aid procedures.

    a. If liquid oxygen gets in the eyes, immediately flood the eyes with water. (See the instructor for the water location.)

    b. If liquid oxygen gets on the bare skin, thaw the area by flooding with water.

    c. Get medical treatment immediately if liquid oxygen gets on the skin or in the eyes.

3. Safety precautions.

    a. Remove all your jewelry now.

    b. There will be NO SMOKING in the oxygen laboratory at any time.

    c. Personnel must wear the proper face shield, apron, and gloves when handling liquid oxygen. This equipment is provided in the laboratory for your use.

d. You must be familiar with sections in TO 15X-1-1 that give points on oxygen safety and servicing equipment. Ask your instructor for the page numbers and paragraphs.

PROJECT NUMBER 1: INSPECTS OXYGEN SYSTEM

PROCEDURE

1. Check all the items on the inspection work card. When you reach step 10, obtain the GO-NO-GO gage from locker #1.

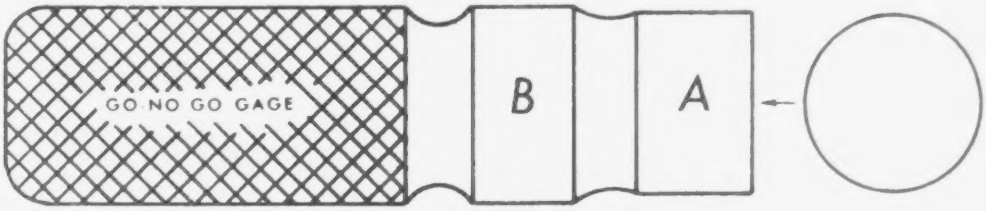

GO NO GO GAGE
B
A
SECTION "A" GO GAGE DIAM 7651
SECTION "B" NO GO GAGE DIAM 768

Figure 1. GO-NO-GO Gage.

2. Use the GO-NO-GO gage to check the inside diameter of the female connector on the mask-to-regulator hose on trainers in the lab. Have the instructor check your work. Identify worn connectors to the instructor.

Note: As shown in figures 1 and 2, "A" of the gage is the "GO" (small diameter) part and "B" is the "NO-GO" (large diameter) part.

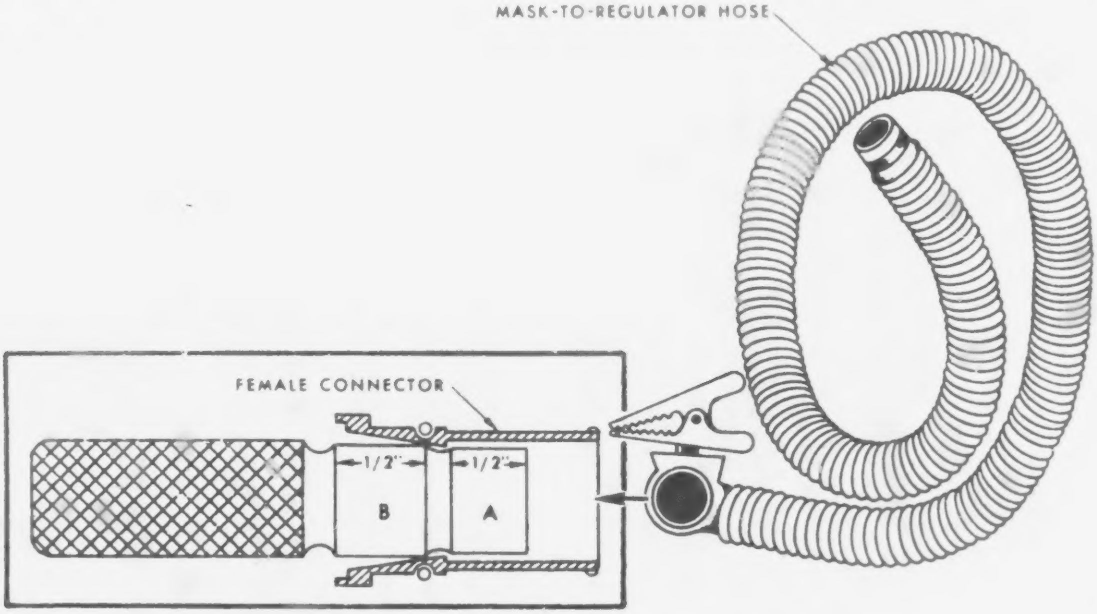

MASK-TO-REGULATOR HOSE
FEMALE CONNECTOR
1/2"
1/2"
B
A

Figure 2. Using the GO-NO-GO Gage.

3. Put the gage in the female connector of the mask-to-regulator hose, as shown in figure 2. Push the gage straight in, but do not force it. A slight rocking or twisting motion may be used.

4. The "GO" part of the gage (A) is small and should slip through the smallest internal diameter of the connector. The "NO-GO" part (B) should not go through the small part of the connector. If it does, the connector has too much wear and must be replaced.

Instructor's Initials __________

PROJECT NUMBER 2: PURGING LIQUID OXYGEN SYSTEM (COLD PURGE)

PROCEDURE

Caution: Due to the special hazards of a training environment, you will work with gaseous nitrogen. Do NOT use the nitrogen trainers for breathing purposes.

1. Prepare the trainer.

a. Check the liquid quantity gage. The system must be empty. If the system is not empty, the liquid oxygen converter will have to be drained. When you work on an aircraft, check the technical order for the proper procedures.

b. Place the oxygen regulator supply switch to ON and the emergency switch to EMERGENCY. This is for the D-2A regulator.

Note: To purge a system on the flight line, first vent the mask-to-regulator hose or hoses to the outside of the aircraft. This can be done through an open canopy, hatch, or entrance way. This will stop the buildup of an oxygen rich atmosphere. An oxygen rich atmosphere is very dangerous.

c. Place the buildup and vent valve to the vent position. Take the handle from the clip and the dust cap from the oxygen filler valve.

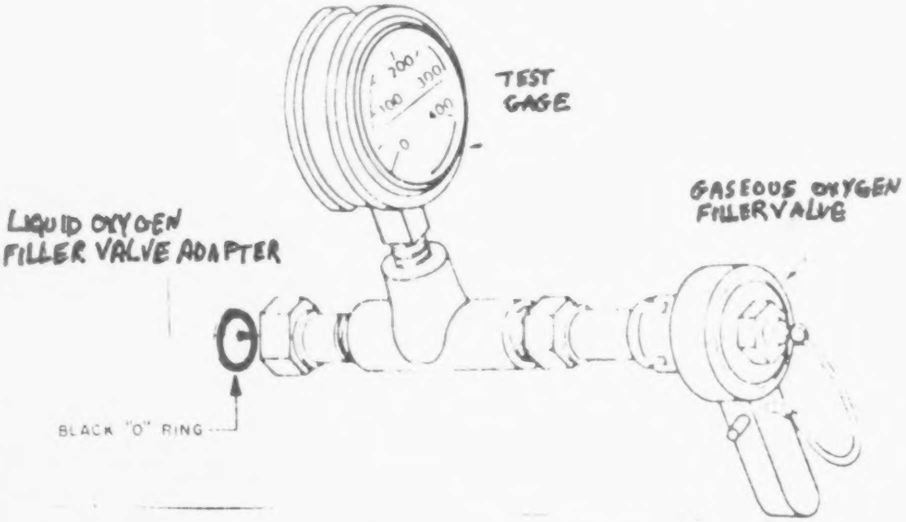

TEST GAGE
100
200
300
400
0
GASEOUS OXYGEN FILLERVALVE
LIQUID OXYGEN FILLER VALVE ADAPTER
BLACK "O" RING

Figure 3. Master Oxygen Test Gage TTU-28/E.

d. Connect the TTU-28/E master test gage to the trainer. Screw the liquid oxygen filler valve adapter of the gage (figure 3) on the threaded part of the liquid oxygen filler valve. Be sure rubber "O" ring is attached to end of filler valve adapter before connecting to trainer. Tighten filler valve adapter using the proper tool.

> Note: On some aircraft, the buildup and vent valve handle would have to be removed to place the system in the buildup position, with the master gage connected. However, on the trainer it is not necessary.

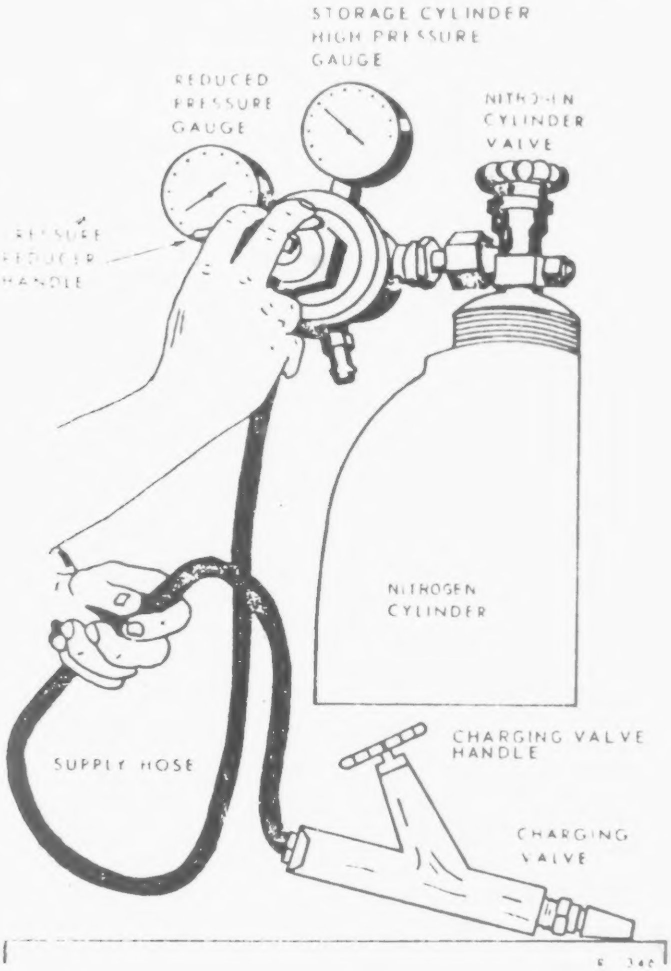

STORAGE CYLINDER
HIGH PRESSURE
GAUGE
REDUCED
PRESSURE
GAUGE
NITROGEN
CYLINDER
VALVE
PRESSURE
REDUCER
HANDLE
NITROGEN
CYLINDER
CHARGING VALVE
HANDLE
SUPPLY HOSE
CHARGING
VALVE

Figure 4. Gaseous Nitrogen Servicing Unit.

2. Prepare the Gaseous Nitrogen Servicing Unit (see figure 4).

a. Check to be sure that the pressure reducer handle is backed out (turn counterclockwise (CCW) and is free to turn (figure 4)).

b. Slowly open the nitrogen cylinder valve and watch the nitrogen cylinder high pressure gage (figure 4). If you have a nitrogen cylinder with a pressure of less than 400 psi, ask your instructor for more instructions before continuing.

Note: Do not drain cylinders below 50 psi. A charge of 50 psi or more in the cylinders will stop the accumulation of moisture in the cylinders.

c. Slowly turn clockwise (CW) the pressure reducer handle (figure 4) until the reduced pressure gage reads 50 psi.

d. Open (CCW) the charging valve handle (figure 4) on the supply hose. Purge the hose for ten (10) seconds. Close (CW) the charging valve. BE SURE TO POINT THE NOZZLE AWAY FROM YOURSELF, OTHERS, AND WALLS.

Note: Purging removes any contaminants (dirt or moisture) that may be inside the hose.

e. Connect the charging valve to the gaseous oxygen filler valve (figure 3) on the master test gage. The gaseous oxygen filler valve is a quick disconnect unit. The adapter on the charging valve will lock automatically.

3. Purging the system.

a. Place the oxygen regulator supply switch ON.

b. Open the charging valve on the supply hose.

c. Readjust the pressure reducer handle to keep a flow of nitrogen at 50 psi on the reduced pressure gage to the TTU-28/E test gage.

d. Allow nitrogen to flow through the system for 1 minute.

Note: In the field use the purge time and steps that are in the technical order for the aircraft on which you are working.

e. Close the charging valve on the supply hose.

f. Place the oxygen regulator supply switch OFF.

g. Place the regulator emergency switch to the NORMAL position.

h. Back out the pressure reducer handle on the servicing unit.

Note: The system is now purged. In the field the aircraft should be serviced with LOX within two hours after it has been purged.

i. This ends the project on cold purging. Leave the trainer and servicing unit as is and start on the next project.

Instructor's Initials __________

PROJECT NUMBER 3: LIQUID OXYGEN SYSTEM PRESSURE LEAK TEST

PROCEDURE

1. Be sure that the TTU-28/E test gage and servicing hose are still connected to the trainer.

2. Place the buildup and vent valve handle to the BUILDUP position.

3. Turn the oxygen regulator supply switch to the OFF position.

4. Open the charging valve on the supply hose.

5. Slowly turn IN the pressure reducing handle on the servicing unit. Charge the system to 300 psi. Use the TTU-28/E test gage to check the pressure.

6. Close the charging valve on the gaseous nitrogen supply hose. Disconnect the charging valve from the test gage.

7. The pressure shown on the TTU-28/E test gage is ______ psi.

8. Close the nitrogen cylinder valve and back OUT the pressure reducing handle. Open the charging valve and bleed the pressure from the manifold and charging hose. Be sure to point the nozzle away from yourself, others and walls.

9. Let the system stand for 15 minutes. (30 minutes is normal time for an aircraft system.)

10. The pressure in the system now is ______ psi. Subtract this reading from the first reading. The difference is ______ psi.

MAXIMUM ALLOWABLE PRESSURE LOSS FOR THE 15 MINUTE TEST

5 liter converters	6.0 psi drop
8 liter converters	3.5 psi drop
10 liter converters	2.5 psi drop
20 liter converters	2.0 psi drop
25 liter converters	1.5 psi drop
75 liter converters	none is allowed

11. If leakage is more than the listed value, the leaks will have to be found and identified to your instructor in project number 4.

12. This ends this project. Leave the trainer as is and start the next project.

Instructor's Initials ________

PROJECT NUMBER 4: LOCATING OXYGEN SYSTEM LEAKS

PROCEDURE

1. Use of the ultrasonic leak detector.

Note: Refer to figure 5 as you get the detector ready for use.

a. Take the probe assembly from the top of the carrying case and the lead assembly from inside the cover of the case.

b. Plug the lead into the probe assembly.

c. Plug the other end of the lead into the jack marked PROBE.

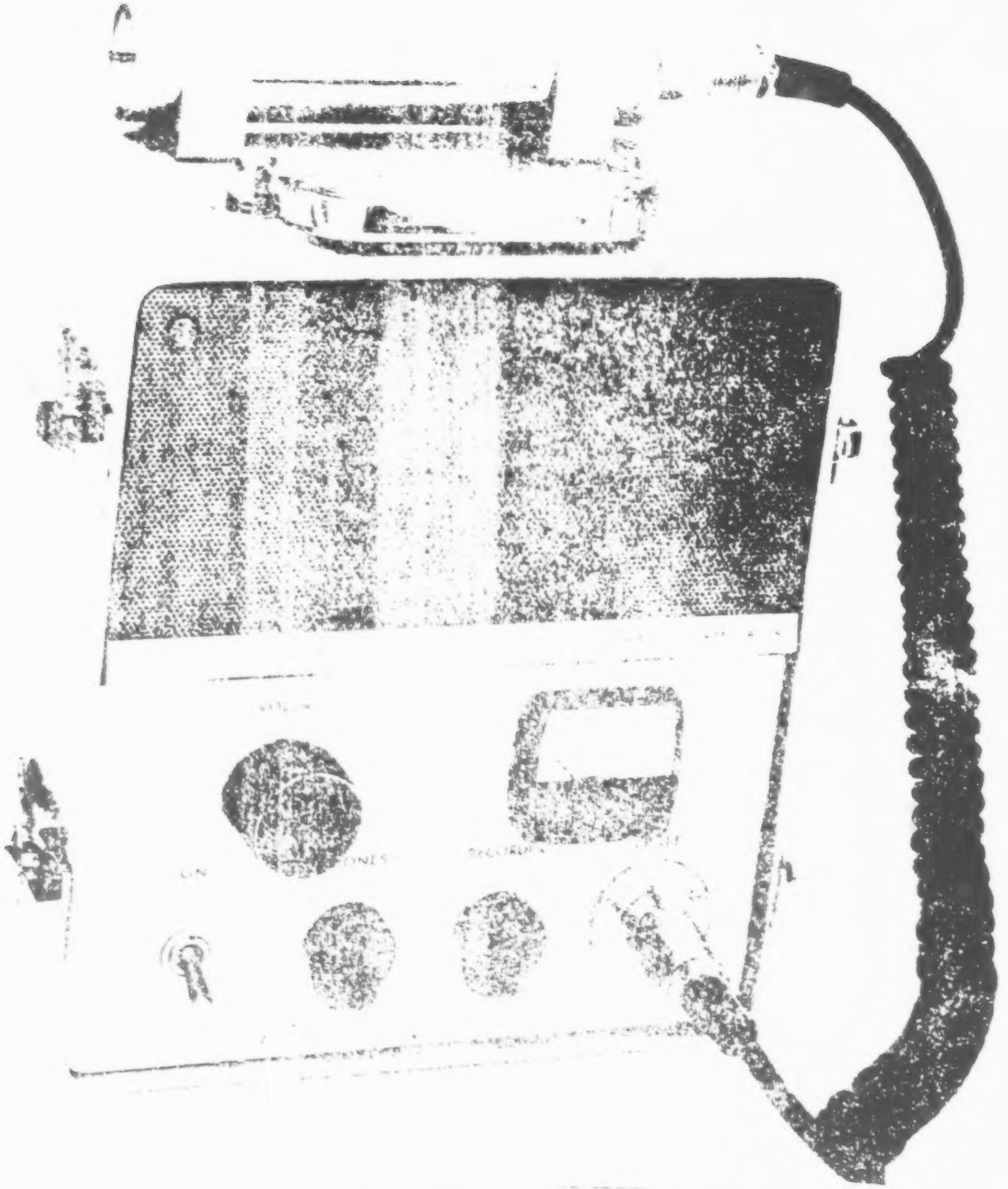


Figure 5. Ultrasonic Translator Detector.

d. Place the switch to the ON position.

e. Turn the volume control to the right to get more volume.

f. Blow into the PROBE to check for sound output. Readjust the volume control if necessary.

g. Slowly move the probe over the tubing and all fittings to check for leaks. A leak will cause the unit to make a sound. As the probe is moved close to a leak the sound will get louder.

h. Have an instructor check your work.

i. Turn the tester switch to the OFF position.

j. If no leaks are found, put the lead assembly back in the carrying case cover, put the probe on top of the case.

2. Use of LEAK TEC (soap) solution.

a. Shake the bottle of LEAK TEC solution well to form small bubbles.

b. Put the solution on the fittings connecting the plumbing and components of the oxygen system trainer.

c. If there is a leak, the LEAK TEC solution will form more bubbles.

d. Be sure to wipe off any excess LEAK TEC solution from the trainer.

e. Slowly move the buildup and vent valve handle to the vent position.

f. After system has been drained, pressure will be trapped in the system and will show on O_2 regulator pressure gage. Bleed off this pressure by turning on the O_2 regulator.

g. Disconnect the TTU-28/E master test gage and put dust cap on filler valve.

h. This ends project for locating leak on O_2 systems.

Instructor's Initials ________

Note: Before proceeding to project number 5, see your instructor. He will direct you to the appropriate trainer to perform the test. Place your readings for the following tests in the spaces provided in the right-hand margin.

PROJECT 5: PURGING THE LIQUID OXYGEN SYSTEM (HOT PURGE)

PROCEDURE

Note: The hot purge kit can be used to purge any liquid oxygen system. The kit can be used to remove moisture from the capacitance probe used with some liquid oxygen converters. Moisture on a probe can cause a wrong signal to be sent to the quantity indicator.

1. Prepare the trainer.

a. The hot purge kit is in locker #1.

b. Move the regulator supply switch to the ON position and the emergency switch to the EMERGENCY position.

c. Vent the mask-to-regulator hose to the side of the trainer. This will drain any remaining system pressure.

d. Place the buildup and vent valve to the VENT position.

e. Take the handle from the clip.

f. Take the dust cap from the filler valve.

g. Place the buildup and vent valve to the buildup position.

h. Take the dust cap from the filler nozzle end of the hot purge kit.

i. Align the three studs (in the open end of the nozzle) with the three grooves on the filler valve on the trainer. (On some aircraft the buildup and vent valve handle will have to be removed for this test.)

j. Push on the nozzle and twist it to the right to lock on the filler valve. Be sure the nozzle is fixed to the valve. Have an instructor check your work before proceeding.

2. Prepare the gaseous nitrogen servicing unit.

a. Check to see that the pressure reducer handle is backed out (CCW) and is free to turn.

b. Slowly OPEN the nitrogen cylinder valve and watch the nitrogen cylinder high pressure gage. If you have a nitrogen cylinder with a pressure of less than 400 psi, ask an instructor for assistance.

c. Slowly turn IN the pressure reducer handle until the reduced pressure gage reads 50 psi.

d. Open the charging valve on the supply hose and purge the hose for 10 seconds, then close the valve.

e. Plug the charging valve into the gaseous oxygen filler valve, on the side of the hot purge kit.

f. Connect the electrical lead from the hot purge kit into a 110V AC, 60 Hz outlet.

3. Purging the system.

a. Open the charging valve on the gaseous nitrogen supply hose.

b. Check the reduced pressure gage to be sure that nitrogen under 50 psi is flowing into the hot purge kit. If not, turn the pressure reducer handle to adjust the pressure to 50 psi. (Nitrogen should flow out the distribution hose from the regulator.)

c. Place the electrical switch, on the end of the hot purge kit, to the ON position. A red light should come ON. This shows that the kit is heating the gaseous nitrogen that flows to the system. This light will cycle ON and OFF as the correct temperature is maintained.

d. Nitrogen should flow through the system for 5 minutes. Aircraft purging time is listed in the aircraft TOs.

4. Disconnecting the hot purge kit.

a. Place the electrical switch to the OFF position.

b. Close the charging valve on the nitrogen supply hose.

c. Place the oxygen regulator supply switch to the OFF position.

d. Place the emergency switch to the NORMAL position.

e. Take the electrical lead from the wall outlet.

Caution: When disconnecting the charging valve from the hot purge kit, lift the kit only by the carrying handle and the insulated portion of the nozzle. This method will prevent burning your hands.

f. Disconnect the hot purge kit from the trainer filler valve.

g. Take the charging valve from the hot purge kit.

h. Put the dust cap on the tester connection and place the hot purge kit back in the carrying case.

i. Put the dust cap on the trainer filler valve and place the buildup and vent valve to the vent position.

j. Place the handle in the clip and place the buildup and vent valve to the buildup position.

5. Secure the gaseous nitrogen servicing unit.

a. Close the valve on the gaseous nitrogen storage cylinder.

b. Open the charging valve on the supply hose and slowly turn IN pressure reducer handle until both pressure gages read zero (0).

c. Close the charging valve.

d. Recheck the gages to be sure they both read zero (0).

e. If pressure still shows on the gages, do steps a through c.

f. The system has been purged with the hot purge kit and should be serviced with liquid oxygen within 2 hours to prevent recontamination.

g. This ends this project.

Instructor's Initials ________

Note: Check with your instructor before continuing.

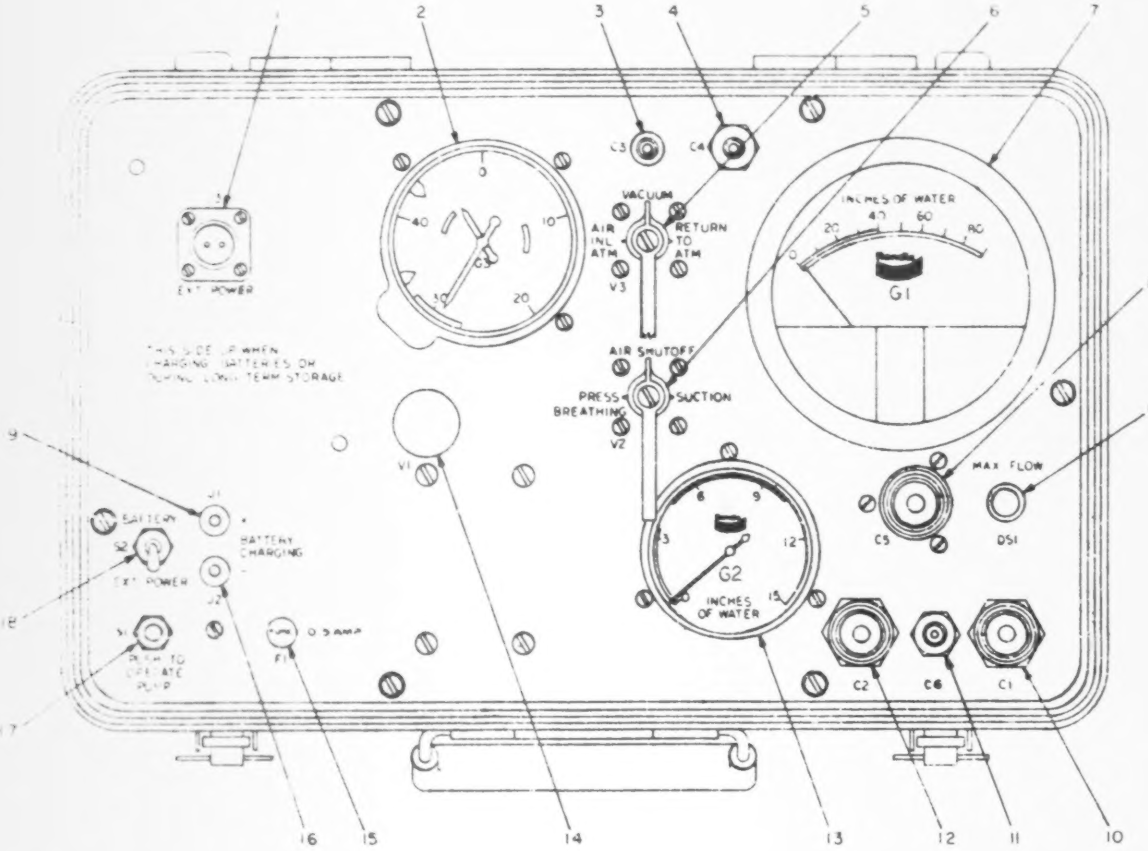
Note: Now you will perform a complete functional check on an oxygen regulator using a field tester that is replacing the MA-2.

PROJECT NUMBER 6: OPERATIONAL CHECK OF AN OXYGEN REGULATOR USING THE 31TA2655-2 FIELD TESTER

Note: An instructor will prepare the trainer for this project.

PROCEDURE

1. Open field tester and remove all hoses and adapters from inside the list. Connect hoses C-3 and C-4 from regulator to tester points C-3 and C-4 and leave connected.


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
C3
C4
VACUUM
AIR INL ATM
RETURN TO ATM
V3
INCHES OF WATER
G1
G3
EXT POWER
THIS SIDE UP WHEN CHARGING BATTERIES OR DURING LONG TERM STORAGE
AIR SHUTOFF
PRESS BREATHING
SUCTION
V2
V1
MAX FLOW
C5
DS1
BATTERY
S2
EXT POWER
J1
BATTERY CHARGING
J2
G2
INCHES OF WATER
S1
PUSH TO OPERATE PUMP
FUSE
F1
0.5 AMP
C2
C6
C1

1	Connector (J3)	10	C1 tube
2	Altimeter (G3)	11	C6 tube
3	C3 tube	12	C2 tube
4	C4 tube	13	Gage (G2)
5	Three-way valve (V3)	14	Valve (V1)
6	Three-way valve (V2)	15	Fuse (F1)
7	Gage (G1)	16	Jack (J2)
8	C5 tube	17	Switch (S1)
9	Lamp (DS1)	18	Switch (S2)
		19	Jack (J1)

Figure 6. 31TA2655-2 Oxygen Regulator Field Tester.

2. Connect the mask-to-regulator hose of the regulator under test to inlet port C-5 of the tester. Refer to figure 6 for reference points on the tester.

3. Connect electrical cable assembly from connector J-3 on tester to a 28V DC outlet located on the wall.

4. Ensure valve V-1 is closed, V-2 to air shutoff, and V-3 to return to atmosphere on tester.

5. On regulator place the supply switch ON, the diluter switch to 100%, and the emergency switch to EMERGENCY.

Note: Put pass or fail in the blanks provided after each test.

6. Normal indication is for light DS1 to illuminate.

a. Return emergency switch to normal.

6. ______

7. Disconnect mask-to-regulator hose from C-5 and reconnect to C-2.

8. Place V-2 to Suction and V-3 to Air Inlet Atmosphere.

9. On regulator the supply switch will be OFF, the diluter switch will be placed on 100%, and the emergency switch will be put into NORMAL.

Note: Do NOT operate pump more than 25 seconds. Pump operation will shut down automatically.

10. Operate pump by depressing S-1 and observe gage G-1. The normal indication should be a reading of .9 inches of water maximum. Any reading within the blue band will be satisfactory.

10. ______

11. Turn oxygen supply switch to the ON position and depress S-1 once again to operate pump.

12. Normal indication will be .4 inches of water maximum on gage G-1. Any reading within the green band will be satisfactory.

12. ______

13. Connect mask-to-regulator hose to C-1 and turn the oxygen regulator supply switch to OFF.

14. Place V-2 to Air-Shutoff and V-3 to Vacuum.

15. Operate pump and observe gage G-3. When the altimeter stops increasing it should lie within the yellow band 27m to 32m.

16. Open V-1 and place V-3 to Return to Atmos. This will return altimeter to sea level.

16. ______

17. Place oxygen regulator supply switch to the ON position. Place V-3 to Air Inlet Atmos, V-2 to Pressure Breathing, and close V-1.

18. Operate the pump and use valve V-1 to control G-3 altimeter at 35M and 43M and take readings from G-2. Readings on G-2 will be in the green band and blue band, respectively.

a. Place V-3 to Return to Atmos, and close V-1.

18. __________

19. Connect the squeeze bulb and reservoir to C-6 and place the regulator supply switch to the OFF position.

20. Pressurize G-2 to 15 inches of water using the squeeze bulb. In 10 seconds the pressure on gage G-2 shall not drop below 4 inches.

20. __________

21. Place oxygen regulator supply switch to the ON position. Plug C-6 on the tester with plug provided. Observe G-2. Pressure should not rise from zero. If it does, monitor the time it takes to go from 1 to 5 inches of water. Time allowed shall exceed 30 seconds minimum.

21. __________

22. Place oxygen regulator diluter switch to Normal, V-3 to Air Inlet Atmos and V-1 to fully OPEN.

23. Connect rubber hose C-4 to inlet C-4 of tester connect outlet hose of regulator to regulator end of C-4 by means of 20 LPM adapter. Operate pump and blinker on regulator should indicate flow.

23. __________

24. Place oxygen regulator diluter switch to 100% and interchange 20 LPM adapter with 8 LPM adapter and operate pump. Blinker on regulator should indicate flow. Remove adapter and reconnect rubber hose to C-4 on regulator.

24. __________

a. Connect outlet hose to C-1.

25. Place oxygen regulator diluter switch to Normal and place emergency switch to Emergency. G-2 should read 2 to 5 inches of water. G-2 reads __________.

25. __________

26. Place the emergency switch to Test Mask. G-2 should indicate greater than 6 inches of water. G-2 reads __________.

26. __________

27. Place all adapters and hoses back into the lid of the tester and close the lid. Be careful not to pinch any hoses when latching the lid.

28. Ensure oxygen regulator supply switch is in the OFF position, emergency switch is in Normal and diluter switch is in Normal. Stow the mask-to-regulator hose on the trainer.

. Instructor's Initials ________

PROJECT NUMBER 7: USING THE TTU-162/E LIQUID OXYGEN CONVERTER TESTER

Note: Use proper LOX safety gear located in locker #2.

1. TEST NUMBER 1 - The vacuum space of the liquid oxygen converter under test needs to be checked for the loss of vacuum. A loss of vacuum will cause a high evaporation rate of the liquid.

a. Check to see that the vent valve is still OPEN.

b. Take the metal flex hose from the exhaust vent of the tester and place them on the bench.

c. Connect one end of the rubber hose to the EXHAUST VENT and the loose end of the hose to the EVAPORATION LOSS FLOWMETER of the tester.

d. Watch the ball in the flowmeter. If the ball rises from zero (0), the amount of leakage is as shown on the markings of the glass tube. The leakage is ________ liters per minute.

e. Use the information in table 1 to choose the leakage that is allowed for the converter under test.

MAXIMUM LOSS SHALL NOT EXCEED	
Converter Size (Liters)	Allowable Leakage (Liters Per Minute)
5	0.60
8	0.69
10	0.75
20	0.92
25	1.0
75	2.1

Table 1. Allowable Converter Leakage.

f. Compare the leakage listed in step d with the leakage allowed for the converter under test. The converter vacuum is (good/bad) ________.

g. Take the hose from the flowmeter and exhaust vent and place the hose on the bench. Reconnect metal flex hose to exhaust vent. Do test number 2.

2. TEST NUMBER 2 - This test is made to find out how much time it takes the converter under test to build up to operating pressure. Operation of the pressure closing valve will also be checked.

a. Close the vent valve on the tester.

b. Open the buildup valve.

c. Maximum buildup time to operating pressure (70 or 300 psi) is 10 minutes. Record the start time __________.

d. Watch the buildup and supply pressure gages. Both gages should rise at about the same rate.

e. At the end of 10 minutes look at the buildup gage. The pressure should be either 70 or 300 psi. Record the pressure. __________ psi.

Note: If the converter does not reach operating pressure in 10 minutes, the pressure setting is out of tolerance (above or below 70 to 300 psi), the pressure closing valve must be adjusted or replaced.

f. The pressure closing valve is (good/bad) __________.

CONVERTER	SPECIFICATION	NO. OF RELIEF VALVES	OP PRESS (PSI)	SIZE (L)	DESIGN FLOW (L/M)
A-2	MIL-C-6650	2	300	8	80
A-3	MIL-C-7407	2 (INDIVIDUAL)	70	5	20
MA-1	MIL-C-25021	2	300	20	120
ME-3	MIL-C-25674	2	300	25	150
GCU-2/A	MIL-C-25777	1	70	10	72
GCU-3/A	MIL-C-25781	1	70	10	72
GCU-10/A	MIL-C-25974	2 (INDIVIDUAL)	300	10	80
GCU-11/A	MIL-C-25972	2	300	10	100
GCU-12/A	MIL-C-25973	1	70	5	72
GCU-14/A	MIL-C-26358	1	70	5	72
GCU-17/A	MIL-C-27336	2	300	25	150
•GCU-20/A	MIL-C-27652	2	300	75	400

Table 2. Converter Data.

3. TEST NUMBER 3 - The converter under test will be checked for maximum and minimum pressures and flow rates. Liquid oxygen converters are made to give a set amount of gaseous oxygen per minute. The amount will change with the type of converter. During this test, the liquid oxygen

that flows into the evaporator coils is changed to a gas that flows overboard through the supply flowmeter.

a. List the temperature that is shown on the temperature gage at the top of the supply flowmeter on the tester. The temperature is ___________.

b. For the converter under test, find the design flow rate in table 2.

c. Watch the float in the supply flowmeter.

d. After the supply valve is opened, stabilize the top of the float at the design flow rate for the converter under test. This is done by opening and closing the supply valve and checking table 2.

e. Let oxygen flow for 5 minutes.

Caution: The evaporator coils and connecting plumbing will ice up during this test. Practice all safety precautions.

f. Watch the pressure gages. The pressure for the converter being tested is listed on the data plate for the converter. If pressure is not in the range set for the converter, the pressure closing valve is not working.

g. The minimum pressure is ______ psi. The maximum pressure is ______ psi.

h. Check the temperature gage. The temperature should be about the same as in step a.

4. TEST NUMBER 4.

a. Put the rubber hose on exhaust vent of tester.

b. Place the other end of the hose on the leakage flowmeter.

c. If the ball in the flowmeter does rise from the zero mark, list the amount of leakage shown. The leakage is ______ LPM.

Number of Relief Valves Installed	Leakage Permitted
1	0.01 LPM
2	0.02 LPM

Table 3. Permitted Relief Valve Leakage.

d. From table 3 find the amount of permissible leakage. Compare this setting with the leakage listed in step g. The reseating of the relief valve is (good/bad) .

e. Take the hose from the flowmeter and converter vent and place the hose on the bench.

f. Reconnect metal flex hose to exhaust vent.

g. Close the buildup valve on the tester and vent the converter head pressure by opening the vent valve.

h. Open the supply valve and bleed off the supply pressure.

i. Close the supply valve.

Note: At this time you would have a serviceable converter or one on which work would have to be done to make it serviceable.

Instructor's Initials __________

PROJECT 8: TF-20-1 CAPACITANCE TYPE LIQUID QUANTITY SYSTEM TRAINER

PROCEDURE

Note: All test leads that will be used are in the cover of the tester. The leads have numbers or letter-number combinations on them for identification. These leads are used with the tester. When you are given a numbered connection point, control switch or indicator in this project, look at the front panel diagram, inside the cover, for the location of the item.

1. Connect adapter lead #100038 from point 5 to a suitable ground.

2. Connect power cable #100033 and adapter cable #100034 together.

3. Connect the combined cable from point 4 to the power source.

4. Place power switch #1 to the ON position. The red light near the switch should come ON.

5. Connect the shielded lead from point 11 to the HI-Z connector of the 10 Ltr converter under test.

6. Connect the coaxial lead from point 12 to the LO-Z connector of the 10 Ltr converter.

7. Set function selector switch #24 to TANK UNIT TEST-UNSH position.

8. Set CAP-RES CHECK switch #13 to CAP position.

9. Set the capacitance RANGE SELECTOR #6 to the lowest range that will give a stable reading (the indicator does not rotate continuously) on capacitance indicator #7. If the inner needle does cross above 100, place the range selector to the next higher multiplier.

10. Complete the statements.

a. The capacitance indicator reading is ______ MMF and the range selector is in the x______ position.

b. The MMF reading multiplied by the range selector position is ______ MMF.

c. Select the required reading from table 4 for the size converter you are testing.

d. The required reading is ______ MMF and the number in step b (is/is not) ______ in the tolerance of the required reading. The converter capacitance probe is (good/bad) __________.

e. Have an instructor check your readings.

Instructor's Initials __________

PROJECT 9: REPAIR AND/OR REPLACEMENT OF LIQUID OXYGEN SYSTEM COMPONENTS

Note: Refer to figure 7 on the following page.

PROCEDURE

1. Remove, repair and replacement of a combination valve.

a. Remove lines and tubing connected to the combo valve, being careful not to twist any lines.

b. Remove common hardware securing the combo valve to the converter assembly.

c. Place the part in a bench vise and remove all old fitting and anti-sieze tape. Have instructor check your work at this time.

d. Remove cap (2), insure chain (1) is disconnected from converter.

e. Remove body seal assembly (4), be careful that the smaller items do not fall out of the valve.

f. Remove poppet valve (5), compression spring (6), helical spring (7), and washer (8) out of the body (9).

g. Rebuilding of the combo valve is accomplished by doing steps a through f in reverse order. Have instructor check your work.

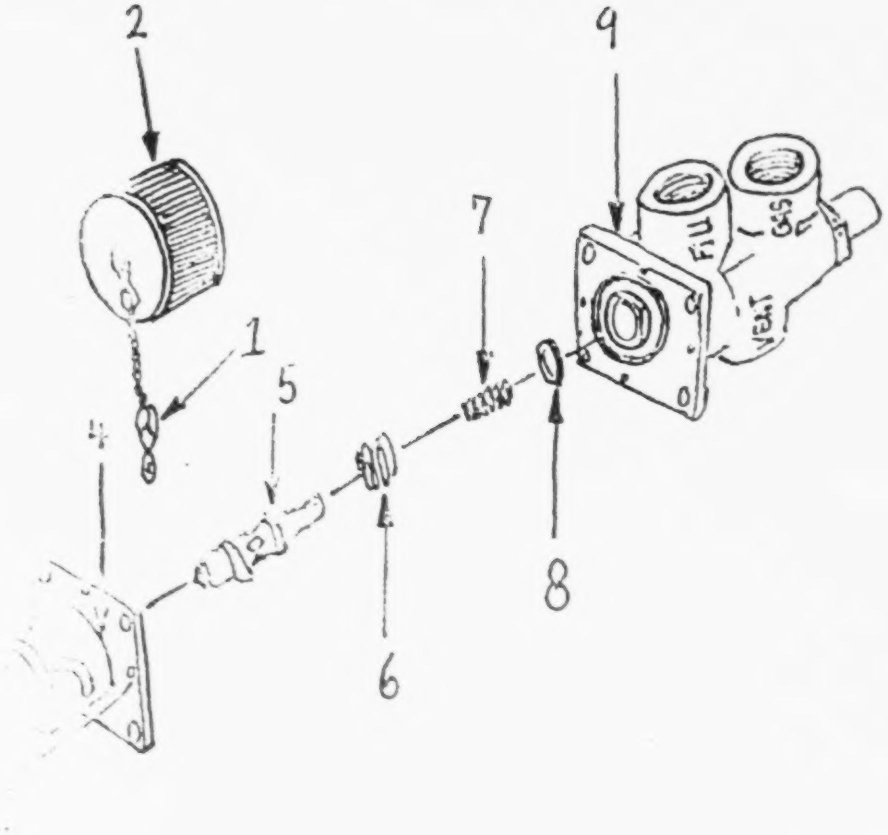
h. Retape fittings and have your instructor check your work. Install the fittings in the same way that they were removed. Follow taping instructions on the anti-sieze tape trainer.

i. Mount the new part on the converter assembly, reinstall all common hardware and tighten.

j. Reinstall and/or connect tubing and lines disconnected during removal, and tighten tubing and lines. Have instructor check your work.

Note: In the field, your converter would now be serviced with a few liters of LOX or gaseous oxygen, for the purpose of leak checking the fittings. All lines found to be leaking would be tightened or replaced to stop the leak.

Instructor's Initials __________


2
9
FILL
GAS
VENT
7
1
5
4
8
6

COMBINATION FILL, BUILDUP AND VENT VALVE

1. Bead Chain
2. Cap
3. Screw
4. Body Seal Assembly
5. Poppet Valve
6. Compression Spring
7. Helical Spring
8. Washer
9. Body

Figure 7.

2. Repair and/or replacement of liquid oxygen converter pressure closing valve or relief valve.

a. On a given converter, remove lines and tubing connected to the part, being careful not to twist any lines.

b. Remove common hardware securing the part to the converter assembly, and remove the part.

c. Place the part in a bench vise and remove all the old fittings and tape.

HAVE INSTRUCTOR CHECK YOUR WORK AT THIS TIME.

Instructor's Initials __________

d. Mount the new part on the converter assembly, reinstall common hardware and tighten.

e. Reinstall and/or connect tubing and lines disconnected during removal and tighten tubing and lines. See your instructor at this time.

SERVICE TEST
PROGRAMMED TEXT

C3ABR42331-PT-403

Technical Training

Aircraft Environmental Systems Repairman

OXYGEN SYSTEM REPAIR AND INSPECTION

15 May 1984

AIR TRAINING COMMAND

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB.

OBJECTIVES

1. Using the necessary tools, equipment, applicable TOs, and workbook repair selected components of an oxygen system.

INSTRUCTIONS

This programmed text is in small steps called "Frames." The PT supports the lesson given in the classroom or lab. Read each frame carefully. At the end of some of the frames you will find a number of statements which ask you to select the statements that are TRUE. The answers will be found on the next page. If you answer the questions correctly, proceed on. If you are wrong or in doubt, restudy the frame until you understand the material and correctly answer the statements.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Frame 1

Components that have failed to work properly or that you have found defective on an inspection will have to be repaired or replaced. In this PT we will cover general replacement procedures. Remember to always follow procedures as outlined in the applicable TO for all maintenance done on any component.

NO RESPONSE NECESSARY

Frame 2

The removal of the filler valve is a simple process. After you have drained the system, loosen the four mount screws that hold the valve to the aircraft. Disconnect the end B-nut connection from the supply line. The filler valve may then be removed for repairs or replacement as necessary.

NO RESPONSE NECESSARY

Frame 3

Normally, no repair is authorized on check valves. Before removing and replacing a check valve, drain the oxygen system. Then disconnect both B-nuts and replace the valve. When you have reconnected the B-nuts torque them to the proper value as shown in the applicable TO.

Select the following statements that are true.

___ 1. Always follow removing and replacing procedures as outlined in your CDCs.

___ 2. The oxygen system must be drained prior to removing the check valve.

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Answers to Frame 1: No Response
Answers to Frame 2: No Response
Answers to Frame 3: F 1. T 2.

Frame 4

Environmental systems personnel do not fabricate (make) tubing assemblies for replacement or installation. However, you do frequently install tubing that has been made by other maintenance personnel. This installation can cause serious consequences if it is not properly done. For example, not too long ago an oxygen system repair was made on an aircraft. The work was perfect, except for a small, not easily detectable oxygen system leak. At another time, on the same aircraft, a repair was made on hot bleed air ducting near the location of the previous oxygen system repair. This work also was perfect except for a small, not easily detectable hot air leak. Neither of these discrepancies alone caused any trouble, however, the small oxygen leak at the same location as the small hot air leak, it is believed, resulted in the destruction of the aircraft and the death of the flight crew. The point is: KEEP OXYGEN AWAY FROM HIGH TEMPERATURES! When installing components of oxygen systems, make doubly sure all fittings are torqued and leak checked in accordance with the technical order instructions.

NO RESPONSE NECESSARY

Frame 5

An authorized antiseize (sealing) tape is used on pipe-thread connections. Use 1/4 inch wide tape on connections up to 1/2 inch diameter size. On 1/2 inch diameter or larger connectors use 1/2 inch tape. The teflon tape is applied to male threads (pipe-thread) only. Wrap the tape in the direction of the thread spiral starting with the first thread. Take care that the tape does not extend over the end of the fitting where it may enter the line of flow. Use one wrap around the threads with a short overlap on the end. The tape should never be applied to the tubing flares or flared-tube threads, since it will prevent proper sealing and cause leakage.

Select the statements that are TRUE.

____ 1. 1/4 inch wide tape must be placed on fittings that are 1/2 inch or smaller in size.

____ 2. Anti-seize tape is applied to flared-tube type connectors.

Answers to Frame 4: No Response

Answers to Frame 5: T 1. F 2.

Frame 6

Removal, replacement, and leakage check are the only authorized actions that are allowed at the intermediate level of maintenance on oxygen regulators. When replacing regulators you must tape the pipe thread end of the fitting; then use a torque wrench for tightening it. Overtightening of the fittings will cause the female fittings to crack. Overtightening or undertightening is the cause of most leaks in an oxygen system. The proper use of a torque wrench on all fittings and B-nuts would get rid of this problem.

NO RESPONSE NECESSARY

Frame 7

Always hold fittings from turning when torquing tubing or hoses to it. This prevents overtorquing of the fitting and twisting of the tubing or hose. Also hold the fittings when loosening B-nuts to prevent twisting of tubing or hose. Flexible hose is used where units are shock mounted, or access to the unit is hard.

NO RESPONSE NECESSARY

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Answers to Frame 6: No Response

Answers to Frame 7: No Response

Select the statements that are TRUE.

___ 1. Check valves are repaired at intermediate level.

___ 2. Oxygen should be kept away from high temperatures.

___ 3. The only maintenance actions allowed on oxygen regulators at our level are removal, replacement and leak check.

___ 4. All removing and replacement should be done as outlined in the applicable TO.

___ 5. Torque wrenches should be used on fittings and B-nuts.

Answers: F 1. T 2. T 3. T 4. T 5.

Frame 8

Now we are going to take a look at inspecting and repairing liquid oxygen systems.

The inspection requirements for each aircraft are found in its -6 technical manual and in its inspection workcard sets. These inspection requirements vary somewhat from one aircraft to another, depending to the type of equipment installed. Therefore, for training purposes, the inspections of the units given in this text will be of a general nature.

NO RESPONSE NECESSARY

Frame 9

All oxygen tubing and equipment throughout the system to make sure that at least 2 inches of clearance exists between oxygen system components and control cables, or other moving aircraft parts. When possible, and where necessary, bend or reroute oxygen tubing to maintain 2 inches of clearance. Tubing should be checked for security of mounting, that is, it does not vibrate or chaff. Make sure they are free of damage, excessive dents, and loss of vacuum. Loss of vacuum can be determined if the container is frosted over. Check the oxygen regulators for proper operation and free of damage. Also check the oxygen hose for any damage and that they are properly routed.

NO RESPONSE NECESSARY

Frame 10

Now lets take a look at some general removing and replacing procedures. Remember to always follow the instructions as outlined in the applicable technical orders.

NO RESPONSE NECESSARY

BEST COPY AVAILABLE

Frame 11

When disconnecting lines on a converter that is bad, wear protective clothing and a face shield since the converter that is bad may not have drained completely. One factor that tends to be of great importance in the maintenance of liquid oxygen systems is the proper technique to use when working pipe thread fittings. When you install replacements fittings a good practice to follow is to remove the fittings one at a time from the converter. Then immediately install the new one or the same one in the new converter. This practice helps to get the fittings properly aligned in the converter for connection to system tubing.

NO RESPONSE NECESSARY

Frame 12

Torque all fittings and B-nuts as outlined in the applicable TOs. This will prevent overtightening or undertightening of the fittings or B-nuts.

NO RESPONSE NECESSARY

Frame 13

You should have no difficulty in performing maintenance on the oxygen system. Keep in mind however, that the converter must be completely empty before any maintenance can be performed on it.

NO RESPONSE NECESSARY

OBJECTIVES

2. Using tools, inspection workcard, applicable TOs, and workbook inspect the cryotainer and components.

3. Using assigned cryotainer, proper tools, applicable TOs, and workbook, remove and replace a minimum of three components.

Frame 1

Liquid oxygen must be kept free of contamination; otherwise, serious consequences may result. Aviator's breathing oxygen with odors (contamination) can cause adverse physical symptoms and disorientation. A contaminated supply will cause noxious and nauseating odors which may adversely effect the pilot's efficiency or cause malfunction of the liquid oxygen system components. Odors may accumulate in LOX that are not identifiable or delectable by regular methods. However, these odors may be detected by an individual with a good sense of smell. Thus, the simple sniff/odor test is a good indicator of contamination. All personnel working with liquid oxygen storage and transfer equipment should take every possible precaution to maintain the quality of the liquid oxygen supply and prevent contaminants from entering into the system during repairs.

NO RESPONSE NECESSRY

Frame 2

If the equipment is in daily use, clean the fill and service line filters every 6 months or sooner if the filters appear to stop or restrict the flow of liquid. The filters should be cleaned with trichloroethylene. After the filters are cleaned you should let them air dry. All traces of trichloroethylene should be gone (should not smell of) before installing.

NO RESPONSE NECESSARY

Frame 3

Gages that are not kept in proper working order can cause trouble. A faulty pressure gage may read too high or too low. When you find a faulty pressure gage you must replace it. Capacity gages should also be checked for proper operation. If a faulty gage exists you must replace it.

NO RESPONSE NECESSARY

Frame 4

An annual inspection is required on all relief valves. They should be checked for proper operating pressures and should also be leak checked. If the valve leaks past the seat of the valve the valve must be repaired or replaced.

NO RESPONSE NECESSARY

Frame 5

The liquid oxygen filler valve used to connect the servicing unit transfer hose to the aircraft system is important. You should inspect this component for minor leaks, loose pins, and loose screws. If a filler valve is suspected of leaking, remove and repair the component.

NO RESPONSE NECESSARY

Frame 6

For all cryotainers, you should follow the applicable TOs for your inspection requirements on all the components of liquid oxygen servicing transfer carts and storage units.

NO RESPONSE NECESSARY

LIQUID OXYGEN SERVICING CHECKLIST

This handout will be used with WB-403, Project 10, procedure 4.

Caution: Follow each step in proper sequence. Make sure that you know the location of the emergency shower and eyewash.

1. Position TMU 27/M LOX cart near the TTU-162/E trainer. Make sure the filler hose will reach the converter without stretching or kinking. Lock the parking brake and ground the LOX cart to a suitable ground.

2. On the TTU-162/E position the valves as follows:

Vent valve - Open

Buildup valve - Closed

Supply valve - Closed

Make sure the TTU-162/E vent line is positioned into the drip pan and that the drip pan is clean.

3. Put on safety gear. Make sure face shields are properly adjusted and that aprons and gloves are not torn. Short sleeve shirts will not be worn during the servicing operation.

4. Open the lid on the LOX cart and study the valve positions and colors. Remember that many LOX carts differ in design, so the valve positions will vary. If there are any doubts in your mind about the LOX cart itself, ask your instructor to explain it NOW. Later might be too late.

5. Perform a complete visual inspection of the LOX cart and be sure to include a review of the LOX cart forms AF Form 244 (located inside of the lid). Specific items to check for are:

a. Broken gages

b. Worn grounding reel

c. Evidence of liquid or gas leaks (frosting or hissing sounds)

Note: A large ball of ice formed around the manifold leading to the quantity gage is normal.

d. Excessive wear on the transfer hose and filler nozzle

e. Sufficient quantity of liquid in the cart to complete the service

f. Clean drip pan under the cart vent port

Supersedes 3ABR42331-HO-403, 25 February 1980.
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3370 TCHTG/TTGU-P - 500; DAV - 1
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6. Close the vent valve (red valve).

7. Open the pressure buildup valve (white valve). This valve is open just enough to reach and maintain 30 PSI ± 5 PSI on the pressure gage. If the pressure exceeds this setting, open the vent valve to relieve excess.

> Note: At no time will the buildup valve be open while the vent valve is open. This will cause a steady stream of LOX to pour from the vent port, possibly injuring someone in that immediate vicinity.

8. Open the fill valve (blue valve) and remove the transfer hose from the storage tube. Remove the dust cap from the filler nozzle.

9. Connect the filler nozzle to the purge adapter on the LOX cart (located on the lower right-hand side of the cart as you are facing the valve compartment). Continue purging until you notice a steady flow of liquid from the nozzle. Then disconnect the nozzle and close the fill valve, blue handle.

10. Connect the transfer hose filler nozzle to the filler port on the combination of the converter you will service.

11. Now slowly, 1/2 turn by 1/2 turn, open the fill valve until it is fully open.

12. Now watch the pressure gage on the cart and maintain 30 PSI ± 5 PSI. This is accomplished by use of the vent valve and buildup valve.

13. When the converter is full (evidenced by a steady flow of liquid from the TTU-162/E vent line), shut off the fill valve, close the buildup valve, and open the vent valve fully.

14. Disconnect the filler nozzle from the converter and place the dust cap on. Store the hose and close the lid.

15. Move the LOX cart back to its storage area.

16. Place safety equipment back in locker #3 in the right order and neatly.

Refer to your instructor for further instructions.

STUDY GUIDE

C3ABR42331-SG-404

Technical Training

Aircraft Environmental Systems Mechanic

CRYOTAINER SYSTEMS

2 August 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

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Environmental Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-SG-404

CRYOTAINER SYSTEMS

OBJECTIVE

State general principles relating to the operation of a cryotainer system and units. A minimum of four out of five must be correct.

INFORMATION

This study guide is designed to help you prepare for the measurement test. Material contained in this study guide supports the instructor's lesson and may be used for study material to complete the objective on the progress check.

Note: This information deals with storage tanks. The instructor's lesson deals with transfer carts. There is little difference between the two. This study guide will point out where the difference.

Supersedes ST C3ABR42331-SG-404, 2 May 1984.
OPR: 3370 TCHTG
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3370 TCHTG/TTGU-P - 300; DAV - 1

STORING CRYOGENIC FLUIDS

The storage of cryogenic fluids for a lot of years has caused a problem. No refrigeration system was able to keep this liquid at a temperature low enough to keep it in a liquid state. Now liquid oxygen and liquid nitrogen can be stored successfully. They are stored in the same way. Since our first concern is the storage of liquid oxygen, this Programmed Text refers to liquid oxygen.

Liquid oxygen must be kept at a very cold temperature (below -297°F) to keep it in a liquid state. Any heat causes it to boil and gas off. You can see the gassing off process taking place in water. Water will boil and gas off to a water vapor, when its temperature is raised above the boiling point. The more heat added to a liquid, the more it boils and evaporates.

There is no low cost way of refrigerating liquid oxygen to keep it in a liquid state; therefore, the only practical way to store it is to try to keep heat from getting to it. This is done by use of a cryotainer.

LOX must be kept in insulated tanks to stop it from boiling and thus changing from a liquid to a gas. To slow this boiling action down, one tank is placed inside another. The inner tank holds the liquid. The outer tank aids in insulating the inner tank. The space between the two tanks (annular space) is filled with an insulating material. A vacuum pump is attached to the line at the top of the tank. The vacuum valve is then opened and the air is pumped out. The valve is then safety wired shut to stop accidental opening. This valve will be color coded yellow and may be letter coded "A". These two items, the insulating material and vacuum in the annular space, provide the insulation for the inner tank. (See figure below.)

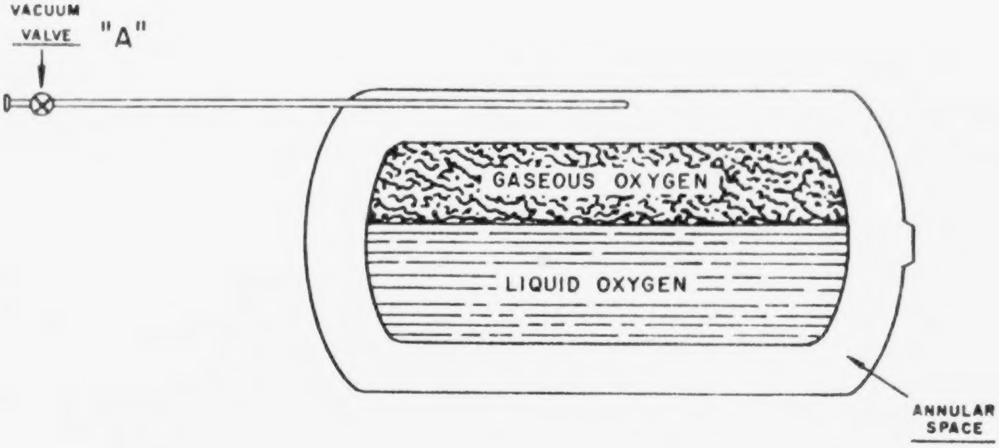


Figure 1.

CONTROL VALVES

There are 3 main control valves. All are the globe type with extended stems. The extended stem prevents the packing from freezing and reduces heat transfer from the hand-wheel to the valve body. The valve body is at the temperature of the liquid oxygen while the hand-wheel is cool to the operator.

There are two pipes that come from the inner tank. The top line from the inner tank is the vent pipe and has the vent valve attached. This valve is only closed when transferring (dispensing) liquid. At all other times, this valve will be open to let the liquid that is vaporizing, out of the tank. The valve is color coded red and may be letter coded "E". (See figure below). The line from the bottom inner tank is the fill and drain line with the fill and drain valve attached. The valve will be color coded blue and may be letter coded "C". This valve will only be opened when issuing or receiving LOX. On transfer carts, you will have two separate valves. Fill and drain, for filling and draining the cart, this is color coded green. The second valve will be your transfer valve, opened only when transferring liquid. This valve will be color coded blue.

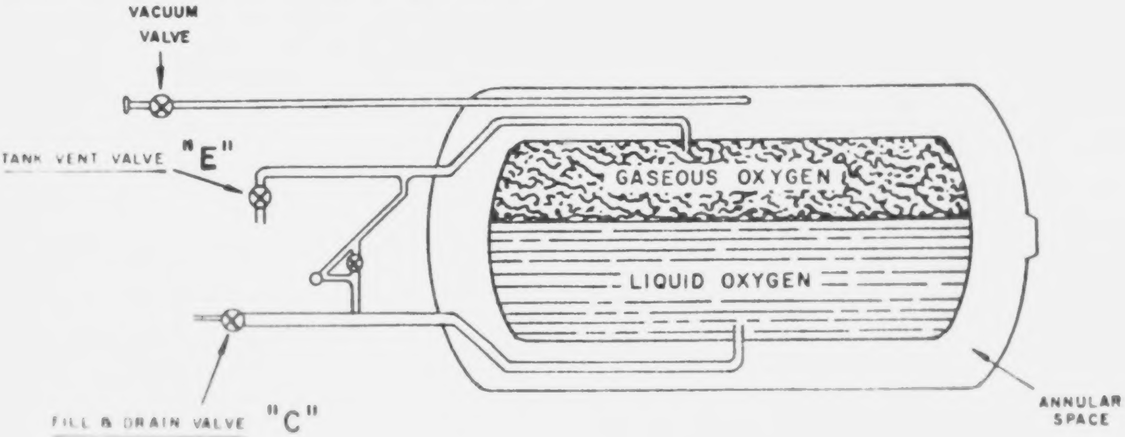


Figure 2.

CAPACITY GAGE AND CAPACITY GAGE BY-PASS VALVE

Located on the pressure line that connects the vent pipe and the transfer pipe is a capacity gage. As the name states, this gage shows the amount of liquid oxygen within the inner tank. This gage is sensitive to pressure and it can be damaged by pressure surges. Therefore, the gage is offset from the pressure line and is protected by a capacity gage bypass valve located in the pressure line.

The valve located in the pressure line is a safety device that protects the capacity gage. This valve is normally open, allowing pressure to "bypass" (go around) the capacity gage. The bypass valve should be closed only when you need to obtain the amount of LOX in the tank. As soon as you have obtained the amount of LOX within the tank, the bypass valve should be opened again. This valve will be color coded black and may be letter coded "B". (See figure below)

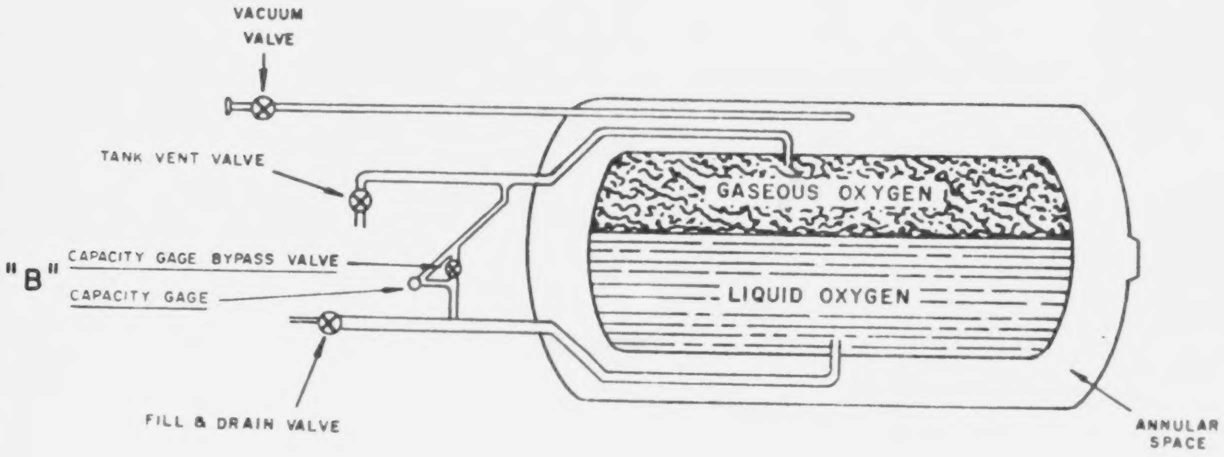

VACUUM VALVE
TANK VENT VALVE
"B"
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
FILL & DRAIN VALVE
GASEOUS OXYGEN
LIQUID OXYGEN
ANNULAR SPACE

Figure 3.

RUPTURE DISC

Earlier in this text we said that pressure buildup within the LOX tank can (under the right conditions) present a hazard to personnel and equipment. For example, if the shell of the inner tank should rupture and leak liquid oxygen into the annular space between the inner and outer tanks, there could be a dangerous buildup of pressure between the two tank shells. To prevent the outer tank from being damaged or blown up from excessive pressures, a safety device is installed in the shell of the outer tank. This safety device is a rupture disc. The rupture disc is set to blow out at a pressure low enough to prevent damage to the outer tank shell. Since LOX tanks are made by several different companies and since each company has different pressure settings on the tanks' safety devices, we will not discuss the pressure settings of these safety devices in this text. (See figure below).

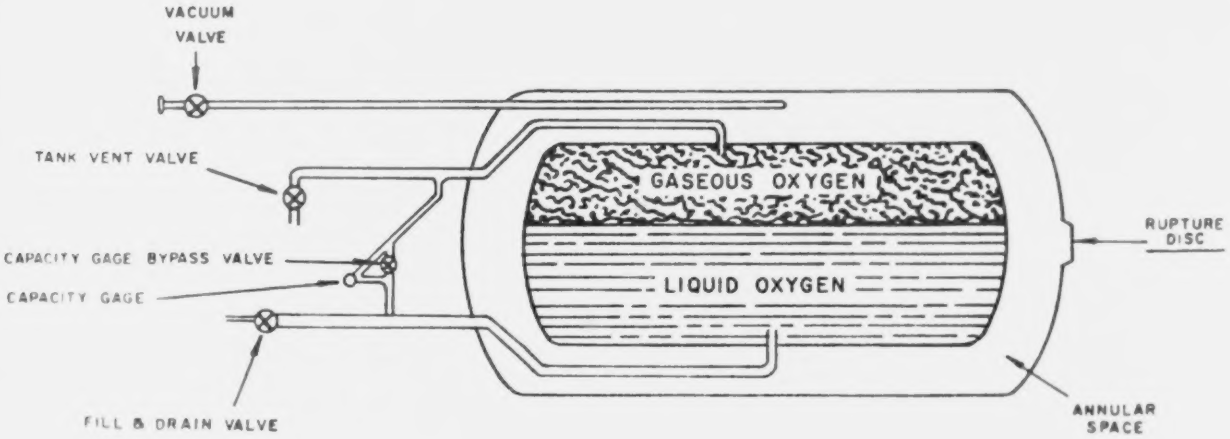

VACUUM VALVE
TANK VENT VALVE
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
FILL & DRAIN VALVE
GASEOUS OXYGEN
LIQUID OXYGEN
RUPTURE DISC
ANNULAR SPACE

Figure 4.

1372

BUILD-UP VALVE

LOX tanks do not have pumps to aid in the rapid transfer of LOX. So some other way must be used to move the liquid. The other way is pressure. As you already know, if the tank vent is closed, pressure will start to build in the tank. But this is a slow process. To speed this process, a pressure buildup valve and coil are attached to the fill and drain line. When the pressure buildup valve is opened (see figure) LOX will flow through the pressure buildup coil (heat exchanger) where it is changed to a gas. From the heat exchanger, the gas follows the pipe which joins the tank vent pipe (remember the tank vent is closed). The gas will then flow back into the gaseous portion of the tank and will apply added pressure to the liquid which allows a more rapid transfer of LOX. This valve will remain closed except when building up pressure in the tank. The pressure buildup valve will be colored coded white and may be letter coded "D".

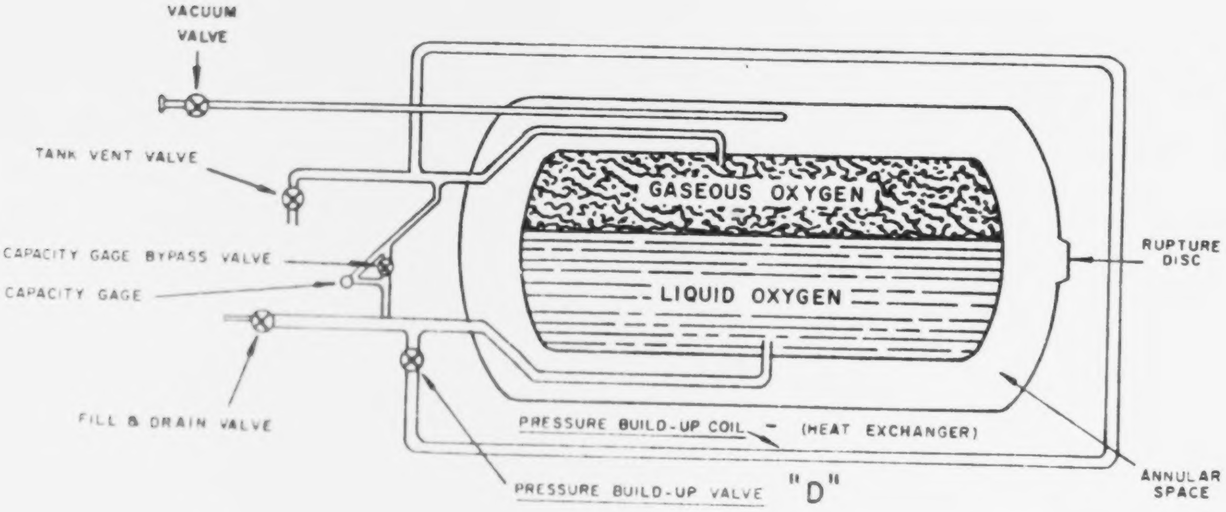

VACUUM VALVE
TANK VENT VALVE
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
FILL & DRAIN VALVE
GASEOUS OXYGEN
LIQUID OXYGEN
RUPTURE DISC
PRESSURE BUILD-UP COIL
(HEAT EXCHANGER)
ANNULAR SPACE
PRESSURE BUILD-UP VALVE
"D"

Figure 5.

PRESSURE GAGE

Just above the point that the pressure buildup coil joins the tank vent line is a direct reading gage (Pressure Gage). This is used to tell how much pressure is built up within the vapor portion of the inner tank.

TANK PRESSURE RELIEF VALVE

Located just above the pressure gage in the pressure build up line is a protective device, the Tank Pressure Relief Valve. This valve will relieve excessive pressure in the inner tank. (Depending on the type of tank the valve will operate either manually or automatically.) See figure below.

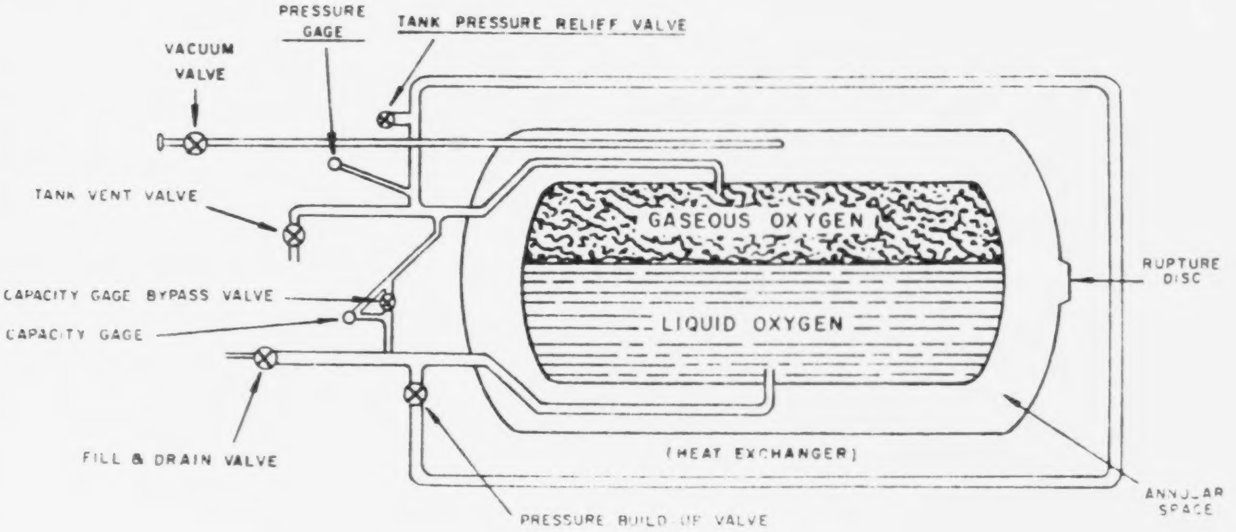

PRESSURE GAGE
TANK PRESSURE RELIEF VALVE
VACUUM VALVE
TANK VENT VALVE
GASEOUS OXYGEN
RUPTURE DISC
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
LIQUID OXYGEN
FILL & DRAIN VALVE
(HEAT EXCHANGER)
ANNULAR SPACE
PRESSURE BUILD UP VALVE

Figure 6.

TRANSFER HOSE

Before we talk about the next relief valve, let's learn about the unit it protects. This is the LOX cart transfer hose.

The transfer hose does just what its name implies--it transfers liquid oxygen through the hose from one container to another. The hose, like the LOX cart, has to be insulated to prevent the liquid oxygen from turning into a gas. It also prevents the operator from frostbite due to the extreme temperature of LOX.

The hose is made up of 3 parts -- (Ref to figure 7), the inner hose, the corrugated hose and the scuff guard. The inner hose, is the part that the liquid oxygen flows through. The hose is made of a special rubber and the diameter is about the size of a dime. The corrugated hose is made of a metal braid and acts as an insulator. The last part of the hose is the scuff guard. The guard is used to protect the corrugated hose from damage. The scuff guard can be removed and replaced but the inner hose and the corrugated hose are a combined unit.

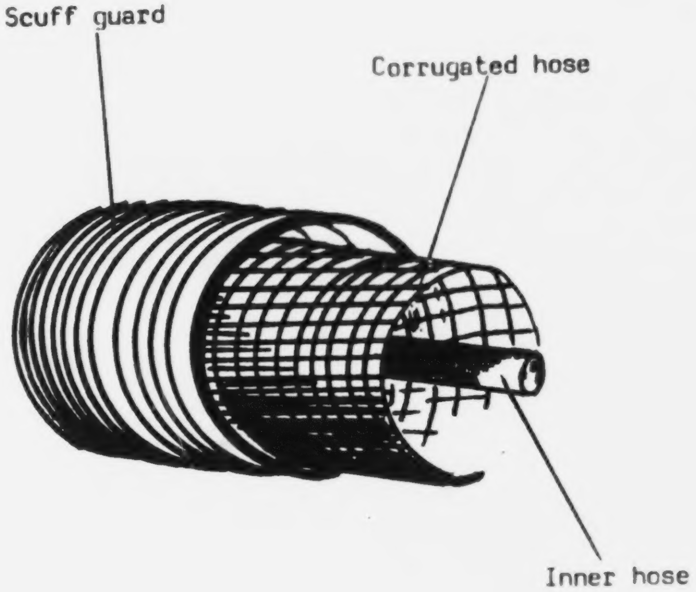
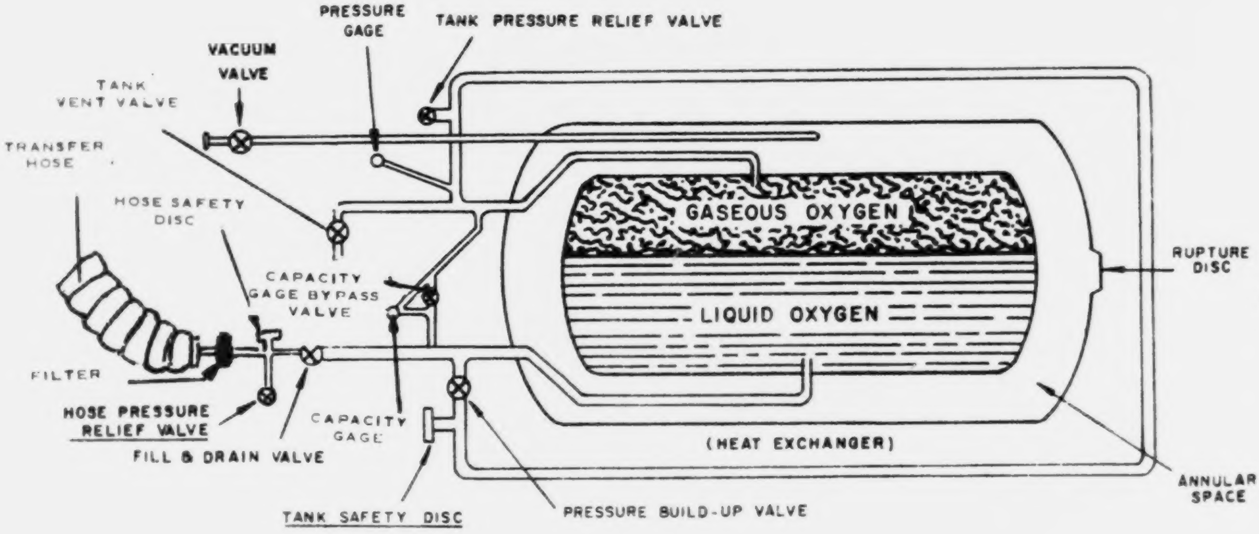


Figure 7. Transfer Hose.

HOSE PRESSURE RELIEF VALVE

The next relief valve is located in the fill and drain line. This is the Hose Pressure Relief Valve. This relieves excessive pressure in the transfer hose and, depending on the type of tank, will be manually or automatically operated. There are two more safety devices, one located in the pressure buildup line and one in the fill and drain line. These are safety discs. If for example, the hose pressure relief valve or tank pressure relief valve were frozen in the closed position, these discs (Hose Safety Disc and Tank Safety Disc) are designed to blow out if the pressure in the hose or tank continued to rise.

The last item is of the Filter located in the fill and drain line. The filter is the metal porous type. This unit, as the name implies, filters LOX.


PRESSURE GAGE
TANK PRESSURE RELIEF VALVE
VACUUM VALVE
TANK VENT VALVE
TRANSFER HOSE
HOSE SAFETY DISC
GASEOUS OXYGEN
CAPACITY GAGE BYPASS VALVE
RUPTURE DISC
LIQUID OXYGEN
FILTER
HOSE PRESSURE RELIEF VALVE
CAPACITY GAGE
FILL & DRAIN VALVE
(HEAT EXCHANGER)
ANNULAR SPACE
TANK SAFETY DISC
PRESSURE BUILD-UP VALVE

Using the diagram, enter the number that correctly identifies the components that make up a liquid oxygen facility. If you are not sure of the answers go back and review the information.

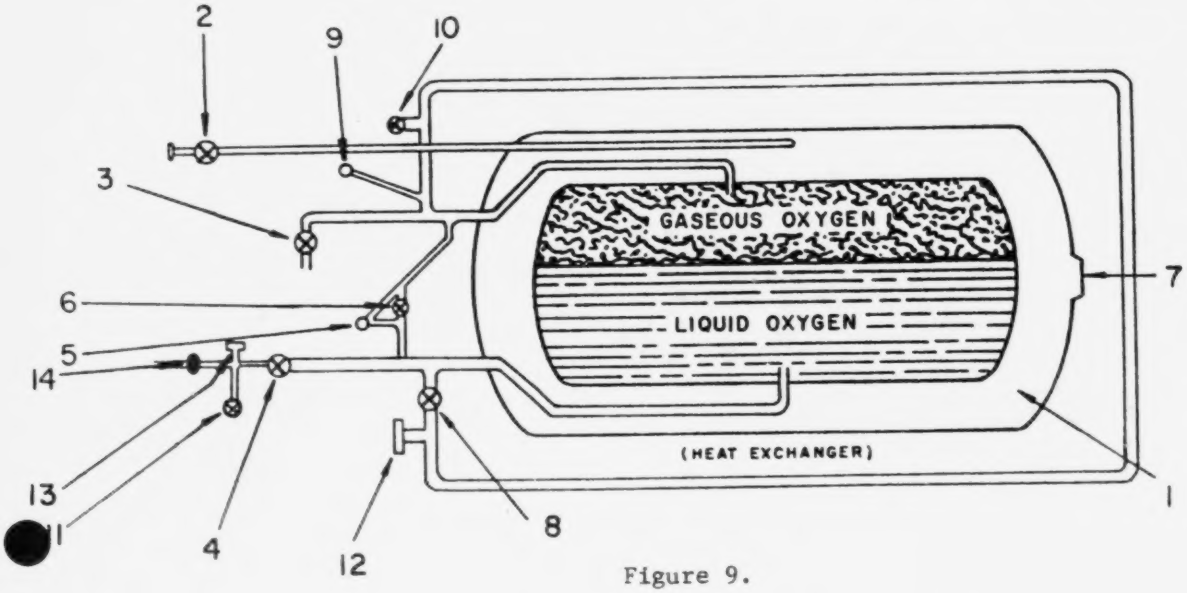

2
9
10
3
GASEOUS OXYGEN
7
6
LIQUID OXYGEN
5
14
(HEAT EXCHANGER)
13
11
4
12
8
1

Figure 9.

a. _____Vacuum valve

b. _____Pressure buildup valve

c. _____Tank safety disc

d. _____Annular space

e. _____Hose pressure relief valve

f. _____Rupture disc

g. _____Hose safety disc

h. _____Tank vent valve

i. _____Tank pressure relief valve

j. _____Fill and drain valve

k. _____Pressure gage

l. _____Capacity gage

m. _____Capacity gage bypass valve

n. _____Filter

SYSTEM OPERATION

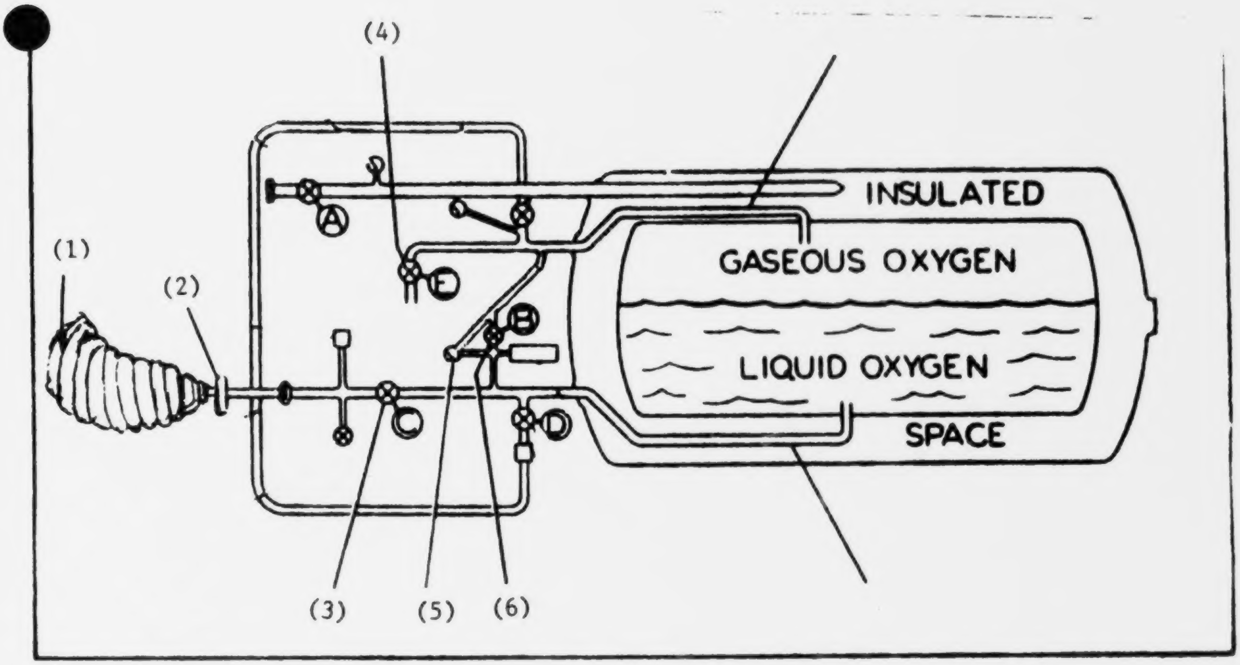
Now we will talk about the complete operation of the cryotainer.

For you to learn the system's operation you must know how to fill the cryotainer. The large storage units used at most bases are filled from a tractor trailer truck just like the ones used to service gas stations with gasoline. Some bases produce their oxygen in a plant type operation and the liquid is pushed right into the tank from the plant, (refer to figure 10). First you must connect the transfer hose (1) to the unit you are going to fill. The connection is made at the fill and drain port (2). Next open the fill-drain valve (3). Now open the vent valve (4), all other valves should be closed. The cryotainer is ready to receive liquid at this time. When liquid is pushed into the cryotainer, it flows from the storage container of the servicing truck through the transfer hose (1) and into the plumbing of the cryotainer. The liquid then flows through the fill-drain valve. After liquid passes through the fill-drain valve it will enter the inner tank of the cryotainer. You will know when the container is full when there is a steady stream of liquid flowing out of the vent valve.

After the receiving tank is full, the transfer hose must be disconnected and stored. Also, a quantity reading will be taken.

Located on the pressure line that connects the vent pipe and the transfer pipe is a capacity gage (5). As the name states, this gage shows the amount of liquid oxygen within the inner tank. This gage is sensitive to pressure and it can be damaged by pressure surges. Therefore, the gage is offset from the pressure line and is protected by a capacity gage bypass valve (6) located in the pressure line.

The valve located in the pressure line is a safety device that protects the capacity gage. This valve is normally open, allowing pressure to "bypass" (go around) the capacity gage. The bypass valve should be closed only when you need to obtain the amount of LOX in the tank. As soon as you have obtained the amount of LOX within the tank, the bypass valve should be opened again.



1. Transfer Hose
2. Fill-Drain Port
3. Fill-Drain Valve C
4. Vent Valve E
5. Capacity Gage
6. Capacity Gage Valve B

Figure 10. Liquid Oxygen Cryotainer.

Select the correct answer for the following questions.

1. The first step when filling a cryotainer is to

   a. start the pump.

   b. connect the transfer hose.

   c. open the fill and drain line.

   d. build up pressure in the receiving container.

2. You know that the tank is full when

   a. the capacity gage reads full.

   b. liquid starts to come out of the vent valve.

   c. the capacity gage reads 5 gallons over the full mark.

   d. liquid flows from the vent valve in a steady stream.

3. When filling a cryotainer, the vent valve should be closed.

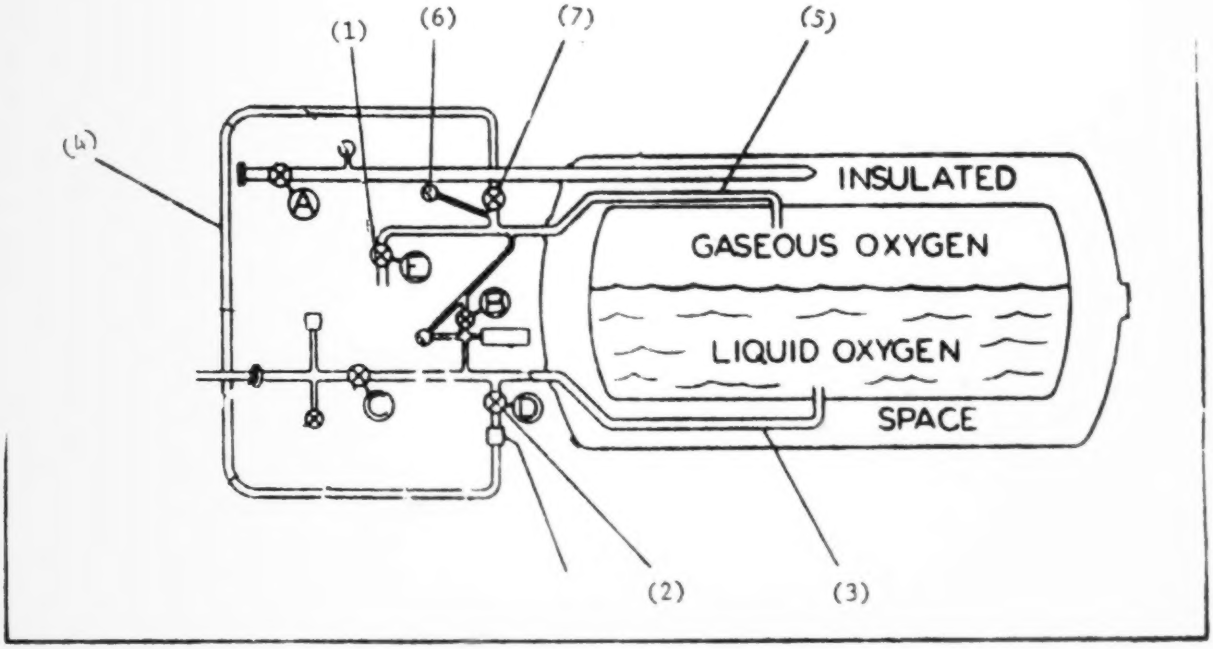
   a. True.

   b. False.

BUILD-UP PHASE

Now that you have learned how to fill a cryotainer, the next phase of operation we will discuss is the buildup phase. The first thing you should do is to close the vent valve (1). The vent valve is closed so that pressure will not be vented out of the cart. The next thing to do is to open the pressure buildup valve (2). When the buildup valve is open, liquid oxygen is drawn from the inner container through the fill-drain line (3) then into the buildup valve (2). The liquid now goes into the buildup coil (4), where the liquid will take on heat and turn into a gas. The gas will travel through the vent line (5) into the top of the tank. At this point, the gas on the top of the inner tank is pushing down on the liquid. During this phase of the buildup operation, it is important that you continually watch the pressure gage (6). Normal operating pressure is 30+ or -5 psig. When you have reached the operating pressure, close the pressure buildup valve (2). This will stop the liquid from being changed into a gas and prevent the pressure from rising any higher. If at any time the pressure should rise above 30+ or -5 psig, insure that the buildup valve is closed (2), then slowly open the vent valve (1). This will vent gas out of the tank. When the pressure is back within the 30+ or -5 psig operating range, close the vent valve.

If pressure was to raise to 50+ or -5 psig the tank pressure relief valve (7) would open and vent pressure automatically. If the pressure relief valve (7) malfunctioned and didn't relieve the pressure, the safety disc would rupture and relieve the pressure in the tank.



1. Vent Valve E
2. Pressure Buildup Valve D
3. Fill-Drain Line
4. Pressure Buildup Coil
5. Vent Line
6. Pressure Gage
7. Pressure Relief Valve 1

Figure 11. Liquid Oxygen Cryotainer.

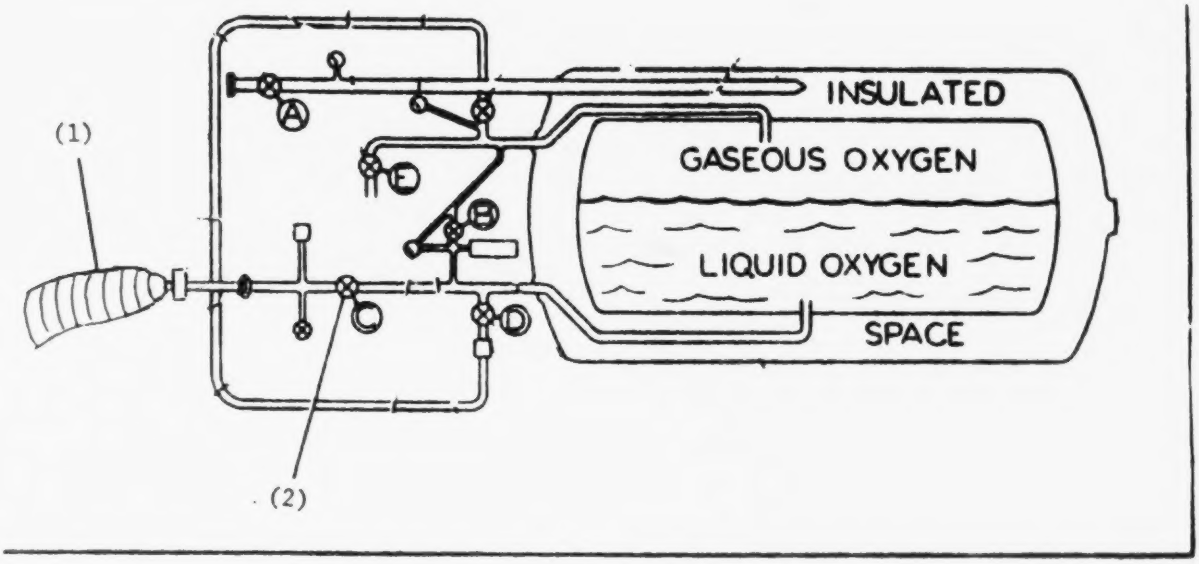
Select the correct answer to the following questions.

1. The first thing you should do in the buildup stage is
    - a. open the vent valve.
    - b. close the vent valve.
    - c. purge the buildup coil.
    - d. open the bypass valve.
2. Operating pressures should not exceed
    - a. 25 psi.
    - b. 30 psi.
    - c. 35 psi.
    - d. 40 psi.
3. After reaching the operating pressure you should
    - a. open the vent valve.
    - b. close the bypass valve.
    - c. close the buildup valve.
    - d. disconnect the transfer hose.
4. What would happen if the pressure of a cryotainer reached 40 psi?
    - a. The inner tank rupture disc would blow.
    - b. Nothing - 40 psi is the normal operating pressure.
    - c. The tank pressure relief valve would relieve excess pressure.
    - d. Nothing - the pressure relief valve relieves at 50 ± 5 psi.

TRANSFER OPERATION

Now let's talk about the transfer operation. The first step in transferring LOX, is to make sure that the LOX tank from which you will transfer (source tank) has enough LOX for the transfer operation. Also insure that you have built up enough pressure in the source tank for transferring LOX. This procedure was talked about in the last frame. Now connect one end of the transfer hose (1) to the fill-drain line on the source tank. Remove the dust cover from the other end of the transfer hose. Place the open end of the transfer hose into a drip pan. Slightly open the fill and drain valve (2) on the source tank. Allow a small amount of liquid to go into the hose, to purge any dust or dirt out of the hose. Close the fill and drain valve on the storage tank.

Now you can remove the dust cover from the fill and drain line on the receiving tank. Connect the transfer hose to the receiving tank. Place all valves on the receiving tank in the same positions described under the fill phase frame.



1. Transfer Hose
2. Fill-Drain Valve C

Figure 12.

1. The first step in transferring LOX is to

   a. build up pressure.

   b. clear out the transfer hose.

   c. make sure you have enough LOX.

   d. remove the dust cap from the transfer hose.

2. What is the position of the valves when transferring LOX?

   a. Vent valve open, buildup valve open, transfer valve open.

   b. Vent valve closed, buildup valve open, transfer valve closed.

   c. Vent valve closed, buildup valve closed, transfer valve closed.

   d. Vent valve closed, buildup valve closed, transfer valve open.

At this point you should be familiar with the construction and operation of a cryotainer system. It is very important for you to know all the components and how they work. If you are unsure of any information given in this PT, go back and review the frames covering the information. If you still have questions, ask your instructor for help. This concludes the PT on the construction and operation of a cryotainer. See your instructor at this time.

1384

WORKBOOK

C3ABR42331-WB-404

Technical Training

Aircraft Environmental Systems Mechanic

CRYOTAINER LABORATORY PROJECTS

22 July 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-WB-404

CRYOTAINER LABORATORY PROJECTS

Objectives

1. Using tools, inspection workcard, applicable TOs and workbook, inspect the cryotainer and components. Locate and record a minimum of four discrepancies on AFTO Form 349. A maximum of two instructor assists is allowed. Apply safety precautions without error.

2. Using assigned cryotainer, proper tools, applicable TOs and workbook, remove and replace a minimum of three components. A maximum of one instructor assist per component is allowed. Apply safety precautions without error.

3. Using a vacuum pump, vacuum micron gage, applicable TOs, workbook, and working in a group of not more than four students, evacuate the cryotainer. A maximum of three instructor assists is allowed. Apply safety precautions without error.

4. Using purging unit, applicable TOs, workbook, safety equipment, and working in a group of not more than four students, purge a cryotainer. A maximum of two instructor assists is allowed. Apply safety precautions without error.

5. Using safety equipment, applicable TOs, workbook and working in a group of not more than two students, perform an operational test of a cryotainer. A maximum of two instructor assists is allowed. Apply safety precautions without error.

6. Using leak tec solution, sonic leak detector, safety equipment, applicable TOs, workbook, and working in a group of not more than two students, perform leak tests on a cryotainer. A maximum of one instructor assist is allowed. Apply safety precautions without error.

INSTRUCTIONS

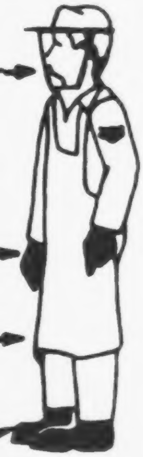
The following workbook deals with the inspection and maintenance of cryotainers. Read each project carefully before starting any work. If you have any questions, be sure and ask your instructor.

Supersedes 3ABR42331-WB-404, 9 March 1982.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Safety

Carelessness in handling cryogenic fluids can result in bodily injury or damage to equipment. The extremely low temperatures can cause severe frostbite (burns) if allowed to contact human skin. High-purity oxygen greatly increases the potential for supporting combustion. Oxygen vapors mixed with such fuels as diesel fuel, tar, rags, or clothing can cause an explosion if ignited. There are many sources of ignition which can result in an explosion. A few of these sources are an open flame, lighted cigarettes, matches, static electricity, or scraping shoe nails against a concrete floor. Always wear tightly woven cotton clothing whenever working with liquid oxygen. Do not wear woolen or nylon clothing because there is danger of static sparks caused by this material. Wear high-top shoes with sewn soles (no nails). Wear your trouser legs outside shoe tops to prevent spilling liquid into your shoes. Note in the sketch what we are talking about. In addition, wear a face shield, loose fitting heavy degreased gauntlet gloves, and a long rubberized or asbestos apron.

These protective devices are mandatory when handling liquid oxygen. Smoking or any other source of ignition must not be allowed within 50 feet of the area where liquid oxygen is handled or stored. Also do not smoke for at least 30 minutes after handling liquid oxygen. Clothing saturated with oxygen vapor could explode with a flash while lighting a cigarette. Provide adequate ventilation in areas where liquid oxygen is handled and stored. It is necessary to ground oxygen tanks during transfer and storage. Keep oil and grease, and any hydrocarbons away from an area where liquid oxygen is stored or transferred. Do not allow equipment to become contaminated. Cleanliness of person, clothing, and equipment is a necessity.



The face shield must cover the entire face.

Depending on which angle you are servicing at, the cuffs will be in or out of your sleeves. If you are servicing with your arms up, the cuffs should be outside of your sleeves. If you are servicing with your arms down, the cuffs should be tucked into your sleeves, as shown in the picture. Use common sense.

The apron must cover the body at least down to the knees. It can be longer.

Shoes must be laced tightly and rubber boots may be worn as additional foot protection. Trouser cuffs must cover the tops of the shoes or boots.

PROJECT 1. INSPECTION

Part of your responsibility as an environmental systems mechanic will be to maintain cryotainers. This will involve not only maintenance, but inspecting the cryotainer also. This project will only involve the inspection requirements for the cryotainer.

At this point refer to the general inspection requirements below:

ITEM	INSPECTED FOR	FREQUENCY
Instruments	Cracked or broken gage faces.	Daily
	Damaged mountings and connections.	Daily
Hose	Excessive scuff guard wear.	Daily
	Frayed wire in braid.	Daily
Fill and Drain Valve	Physical damage and worn or damaged parts.	Daily
Cabinet	Cleanliness and absence of foreign objects.	Daily
	Missing or damaged valve handles.	Daily
Valves	Ease of operation.	Daily
	Leaks in bonnet or packing.	Daily
Brake	Proper and easy operation.	Daily
Tank	General physical condition and loose or missing hardware.	Daily
Tires	Cracks, underinflation, deterioration, or other damage (30 psi pressure).	Monthly
Painted Surface	Corrosion, Rust, Damage, Peeling (Spot paint if deterioration constitutes less than 25 percent of the entire surface to be refinished; if 25 percent or more, refinish entire surface.).	Monthly

Figure 1.

These are only general inspection requirements for all LOX cryotainers. Notice how often these components require inspection. The cryotainer, as a whole unit, also has to be inspected at certain times. These inspections are called periodic inspections. You will have an AFTO Form 26 (inspection workcard) to use as a guideline, showing which components to inspect and what to look for. A Support Equipment Work Unit Code Manual, TO 00-25-06-2-2 is used to find the codes to document the work done on AFTO Forms 349.

At this time, see your instructor. The instructor will assign you a cryotainer to inspect. Use the inspection workcard to inspect the assigned LOX cart and locate four discrepancies. Use TO 00-25-06-2-2 to complete the four discrepancies on AFTO Forms 349. You are allowed a maximum of two instructor assists on this project.

PROJECT 2. MAINTENANCE

When a discrepancy is found on a cryotainer, it should be repaired as soon as possible, whether it be tightening a screw or removing and replacing a component. Keeping all cryotainers in working condition is essential to mission accomplishment.

During this project, you will be required to remove and replace at least three components. The instructor will give you a pre-printed AFTO Form 349. On the 349 will be printed the discrepancy and the cyrotainer ID/serial number. Also, on the back of the 349 there will be deletion steps and notes for you to use along with your TO. After completing the maintenance, you are required to complete the 349, using the work unit code manual. Your instructor will give you one 349 at a time. When you have completed the maintenance and the 349, return the 349 to your instructor to inspect your work.

At this time, see your instructor and obtain a 349 and TO.

PROJECT 3. VACUUM CHECK

As you already know, liquid oxygen must be kept as cold as possible. This prevents it from boiling off - changing from a liquid state to a gaseous state. Keeping the oxygen a liquid is done by removing as much air as possible out of the annular space. This is known as a vacuum. A vacuum is the absence of air. If there isn't a vacuum around the inner tank, heat will transfer from the outer tank, travel through the air in the annular space - to the inner tank. This will cause the liquid in the inner tank to boil off into a gas. When you are in the field, you will be required to check and maintain the vacuum in the cryotainer. To check the vacuum, you use a vacuum gage and thermocouple. The thermocouple is a tubed-type male plug that is connected through piping to the annular space of a cryotainer. Each thermocouple is a precision component and is preset to a certain meter reading (calibrated). When you connect the vacuum micron gage to the thermocouple, be sure that all the pins on the thermocouple line up with the correct holes on the vacuum gage plug. Now you are ready to take the vacuum reading from the vacuum gage. To learn how to do this, obtain TO 37C11-3-1. Read page 1-1, page 1-4, page 2-2 and look at figure 1-2.

The instructor will assign you a LOX cart to check the vacuum on. After you have checked the vacuum IAW TO 37C11-3-1, give the instructor your reading.

VACUUM PROCEDURES

When the micron reading of the vacuum of a cryotainer is greater than the reading specified by the TO, the annular space must be vacuumed to reach the required reading. This is generally referred to as pump down. Prior to the pump down of the vacuum in the annular space, you must make sure that the tank is empty. The component used to vacuum the annular space of a cryotainer is the PMU-4-E vacuum pump. Other pumps are allowed, but you must refer to the TO to insure that a specific pump is authorized.

Refer to figure 1 in TO 34Y5-3-37-11, and become familiar with the various components on the vacuum pump.

At this time, see your instructor. The instructor will give you a pre-printed 349, TOs 37C2-8-3-3, 34Y5-3-37-11 and 37A12-1-101. Follow the procedures in TO 37A12-1-101 for vacuuming the annular space. On the back of the 349 will be additional information that must be followed along with TO 37A12-1-101. While doing the pump down procedures, refer to TO 37C2-8-3-3, figure 5-8 and TO 34Y5-3-37-11, figure 1-1.

PROJECT 4. PURGING

Purging of a cryotainer is the process of forcing heated air or nitrogen through the drained tank, causing contaminants or moisture in the tank to be converted to a gas and removed from the tank. Cryotainers are not purged on a scheduled basis, but rather when the percentages of contaminants reach an undesirable level. This level is determined by either laboratory testing or the odor of particulate testing.

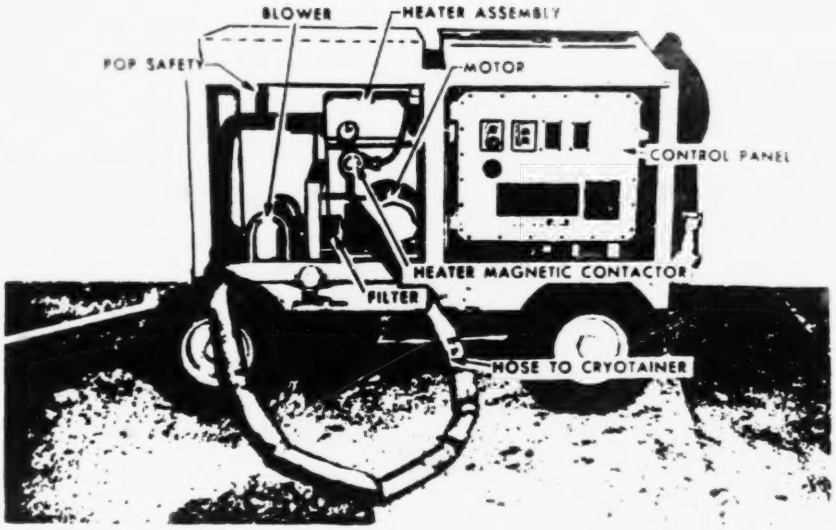
Requirements for draining and purging are found in TO 42B6-1-1. Since the tank you are going to use has already been drained, you will not need this TO.

Evidence of contamination of a storage tank will require all servicing carts to be purged along with the storage tank to assure complete disposal of the contaminated LOX.

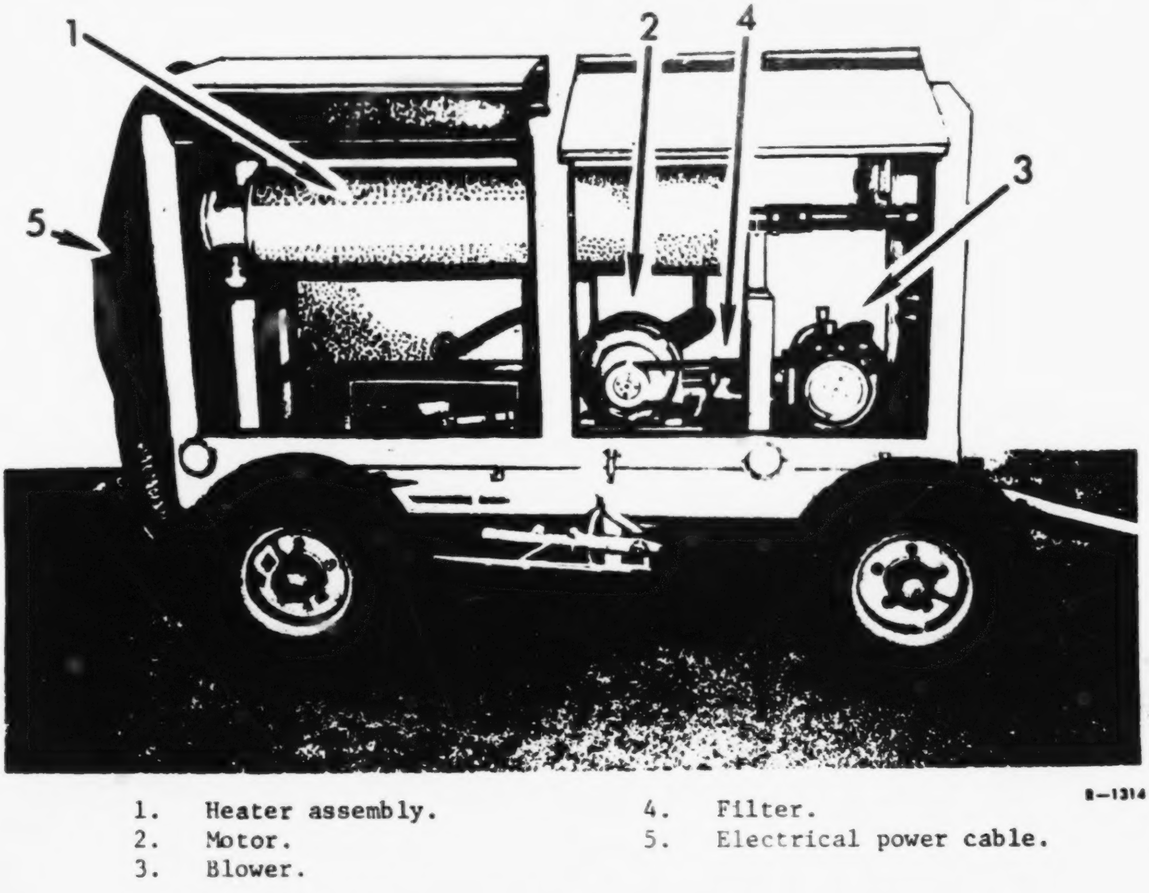
The unit used to purge LOX cryotainers is the GSU-62/M. Refer to figure 2 on the next page.

PURGING PROCEDURES

See your instructor at this time. The instructor will give you a pre-printed 349 and TO 37C2-8-3-3. Follow the procedures for purging a cryotainer along with the exceptions found on the back of your 349.


BLOWER
HEATER ASSEMBLY
POP SAFETY
MOTOR
CONTROL PANEL
HEATER MAGNETIC CONTACTOR
FILTER
HOSE TO CRYOTAINER

Air Purging Unit, Type GSU-6/2/M - Left Side.


1
2
4
3
5
R-1314

1. Heater assembly.
2. Motor.
3. Blower.
4. Filter.
5. Electrical power cable.

Figure 2. Air Purge Unit, Type GSU-62/M - Right Side.

PROJECT 5. OPERATION AND LEAK CHECK OF A LOX TRANSFER CART

As an environmental systems mechanic, you will be responsible for insuring that the LOX transfer carts are operational and that they do not have any leaks.

Use the checklist below and follow all safety and general instructions. Pay strict attention to all procedures, especially safety. If you have any questions ask your instructor. You will be working with liquid nitrogen, therefore, it is of utmost importance that you are sure of what you are doing, BEFORE you do it. Follow each step in proper sequence. Make sure you know the location of the emergency eyewash and shower.

1. Put on proper safety equipment (locker #2). Make sure face shields are properly adjusted and the aprons are not torn. Short sleeve shirts will not be worn during servicing operation.

2. Open the lid on the LOX cart and study the valve positions and colors. Remember that many LOX carts differ in design, so the valve position will vary.

3. Perform a complete visual inspection. Specific items to be checked are:

   a. Broken gages.

   b. Worn grounding reel.

   c. Excessive wear on components.

4. Close the vent valve (RED VALVE).

5. Open pressure buildup valve (WHITE VALVE). This valve is open just enough to reach 25 psi on the pressure gage then close the buildup valve.

6. Using leak tec solution and ultrasonic leak detection and safety equipment perform a leak test of the cryotainer. Identify any leaks to instructor.

7. Open transfer valve (BLUE VALVE), take hose out of container and take off dust cap from the end of transfer hose filler valve.

8. Connect the filler nozzle to purge adapter on the LOX cart (located on the lower right-hand side of the cart as you are facing the valve compartment). Continue purging until you notice a steady flow of liquid from nozzle. Then disconnect the nozzle from the purge adapter. There is now liquid trapped in the transfer hose, now check the transfer hose for leaks also the filler nozzle. If no leaks are found, stow the hose back in container in the same manner that it was removed.

9. You might hear a sudden relief of pressure out of the vent port. This is the transfer hose automatic relief valve relieving pressure buildup in the transfer hose.

10. Open vent valve (RED VALVE), slowly bleed pressure off, be sure buildup valve is closed (WHITE VALVE).

While using this workbook, you learned about the operation and maintenance of a cryotainer. As you progress through your career as an environmental systems mechanic, you will learn more and more about the cryotainer and the associated equipment. The most important thing you can learn about a cryotainer is to be safe and to follow all technical order procedures. No matter how many times you do something, there is always the chance of making a mistake. By using the TO and following it properly, you can eliminate the possibility of error.

This concludes the workbook on cryotainers. At this time, see your instructor for further instructions.

STUDY GUIDE
C3ABR42331-SG-404

Technical Training

Aircraft Environmental Systems Mechanic

CRYOTAINER SYSTEMS

2 August 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

Environmental Pneudraulics Branch
Chanute AFB, Illinois

SERVICE TEST
C3ABR42331-SG-404

CRYOTAINER SYSTEMS

OBJECTIVE

State general principles relating to the operation of a cryotainer system and units. A minimum of four out of five must be correct.

INFORMATION

This study guide is designed to help you prepare for the measurement test. Material contained in this study guide supports the instructor's lesson and may be used for study material to complete the objective on the progress check.

> Note: This information deals with storage tanks. The instructor's lesson deals with transfer carts. There is little difference between the two. This study guide will point out where the difference.

Supersedes ST C3ABR42331-SG-404, 2 May 1984.
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DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

STORING CRYOGENIC FLUIDS

The storage of cryogenic fluids for a lot of years has caused a problem. No refrigeration system was able to keep this liquid at a temperature low enough to keep it in a liquid state. Now liquid oxygen and liquid nitrogen can be stored successfully. They are stored in the same way. Since our first concern is the storage of liquid oxygen, this Programmed Text refers to liquid oxygen.

Liquid oxygen must be kept at a very cold temperature (below -297°F) to keep it in a liquid state. Any heat causes it to boil and gas off. You can see the gassing off process taking place in water. Water will boil and gas off to a water vapor, when its temperature is raised above the boiling point. The more heat added to a liquid, the more it boils and evaporates.

There is no low cost way of refrigerating liquid oxygen to keep it in a liquid state; therefore, the only practical way to store it is to try to keep heat from getting to it. This is done by use of a cryotainer.

LOX must be kept in insulated tanks to stop it from boiling and thus changing from a liquid to a gas. To slow this boiling action down, one tank is placed inside another. The inner tank holds the liquid. The outer tank aids in insulating the inner tank. The space between the two tanks (annular space) is filled with an insulating material. A vacuum pump is attached to the line at the top of the tank. The vacuum valve is then opened and the air is pumped out. The valve is then safety wired shut to stop accidental opening. This valve will be color coded yellow and may be letter coded "A". These two items, the insulating material and vacuum in the annular space, provide the insulation for the inner tank. (See figure below.)

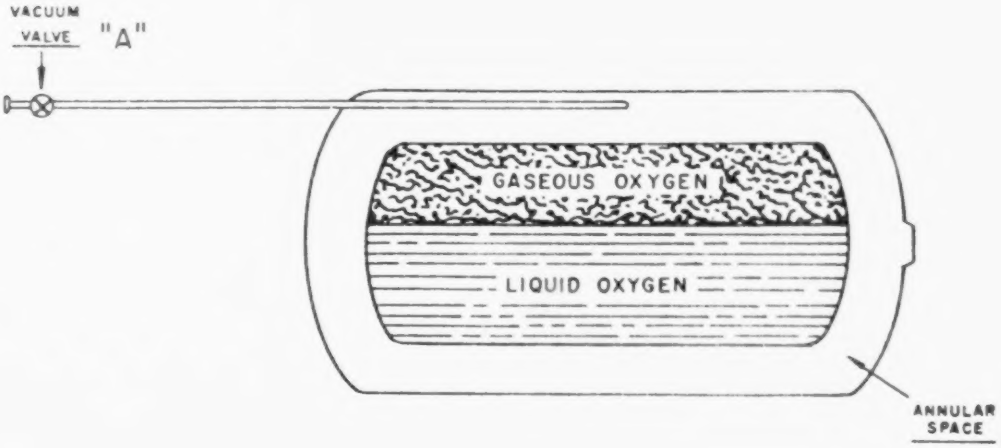


Figure 1.

CONTROL VALVES

There are 3 main control valves. All are the globe type with extended stems. The extended stem prevents the packing from freezing and reduces heat transfer from the hand-wheel to the valve body. The valve body is at the temperature of the liquid oxygen while the hand-wheel is cool to the operator.

There are two pipes that come from the inner tank. The top line from the inner tank is the vent pipe and has the vent valve attached. This valve is only closed when transferring (dispensing) liquid. At all other times, this valve will be open to let the liquid that is vaporizing, out of the tank. The valve is color coded red and may be letter coded "E". (See figure below). The line from the bottom inner tank is the fill and drain line with the fill and drain valve attached. The valve will be color coded blue and may be letter coded "C". This valve will only be opened when issuing or receiving LOX. On transfer carts, you will have two separate valves. Fill and drain, for filling and draining the cart, this is color coded green. The second valve will be your transfer valve, opened only when transferring liquid. This valve will be color coded blue.

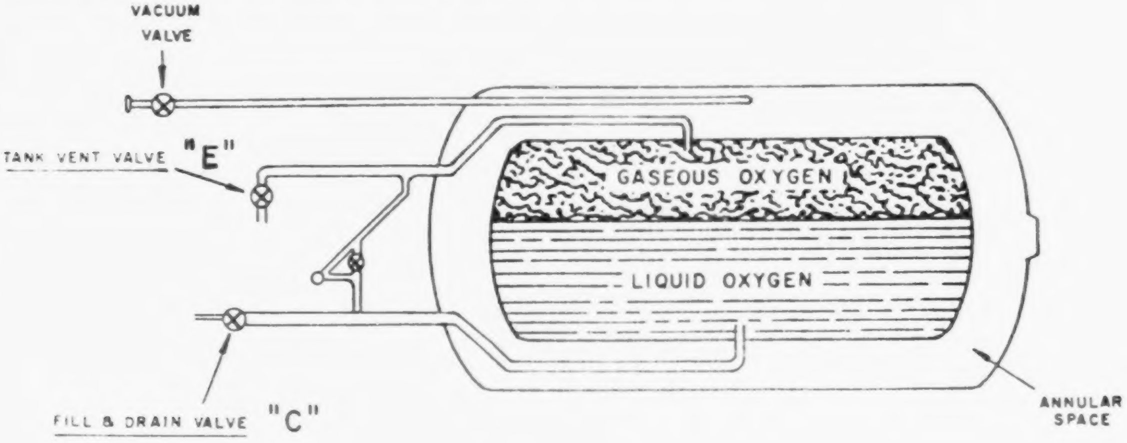


Figure 2.

CAPACITY GAGE AND CAPACITY GAGE BY-PASS VALVE

Located on the pressure line that connects the vent pipe and the transfer pipe is a capacity gage. As the name states, this gage shows the amount of liquid oxygen within the inner tank. This gage is sensitive to pressure and it can be damaged by pressure surges. Therefore, the gage is offset from the pressure line and is protected by a capacity gage bypass valve located in the pressure line.

The valve located in the pressure line is a safety device that protects the capacity gage. This valve is normally open, allowing pressure to "bypass" (go around) the capacity gage. The bypass valve should be closed only when you need to obtain the amount of LOX in the tank. As soon as you have obtained the amount of LOX within the tank, the bypass valve should be opened again. This valve will be color coded black and may be letter coded "B". (See figure below)

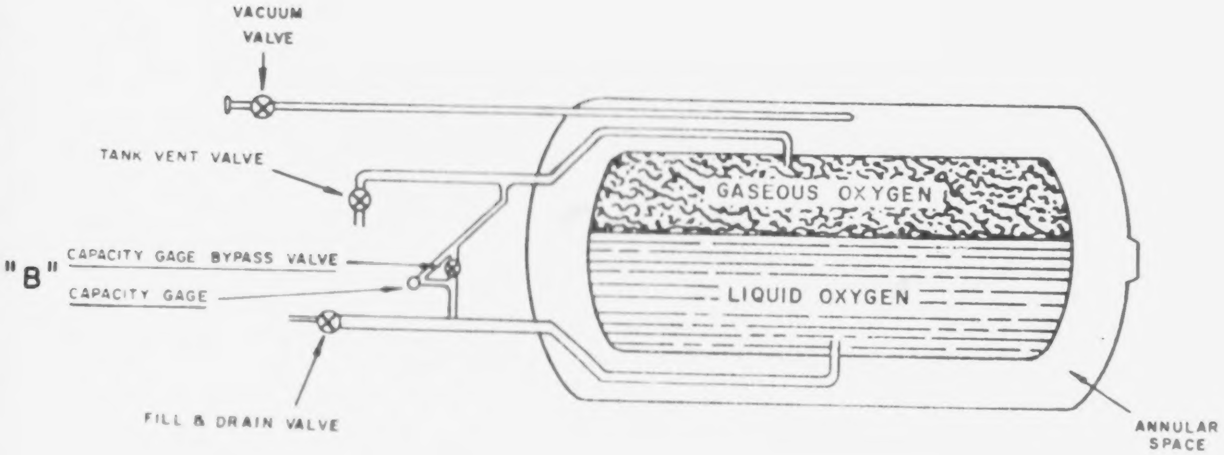

VACUUM VALVE
TANK VENT VALVE
"B"
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
FILL & DRAIN VALVE
GASEOUS OXYGEN
LIQUID OXYGEN
ANNULAR SPACE

Figure 3.

RUPTURE DISC

Earlier in this text we said that pressure buildup within the LOX tank can (under the right conditions) present a hazard to personnel and equipment. For example, if the shell of the inner tank should rupture and leak liquid oxygen into the annular space between the inner and outer tanks, there could be a dangerous buildup of pressure between the two tank shells. To prevent the outer tank from being damaged or blown up from excessive pressures, a safety device is installed in the shell of the outer tank. This safety device is a rupture disc. The rupture disc is set to blow out at a pressure low enough to prevent damage to the outer tank shell. Since LOX tanks are made by several different companies and since each company has different pressure settings on the tanks' safety devices, we will not discuss the pressure settings of these safety devices in this text. (See figure below).

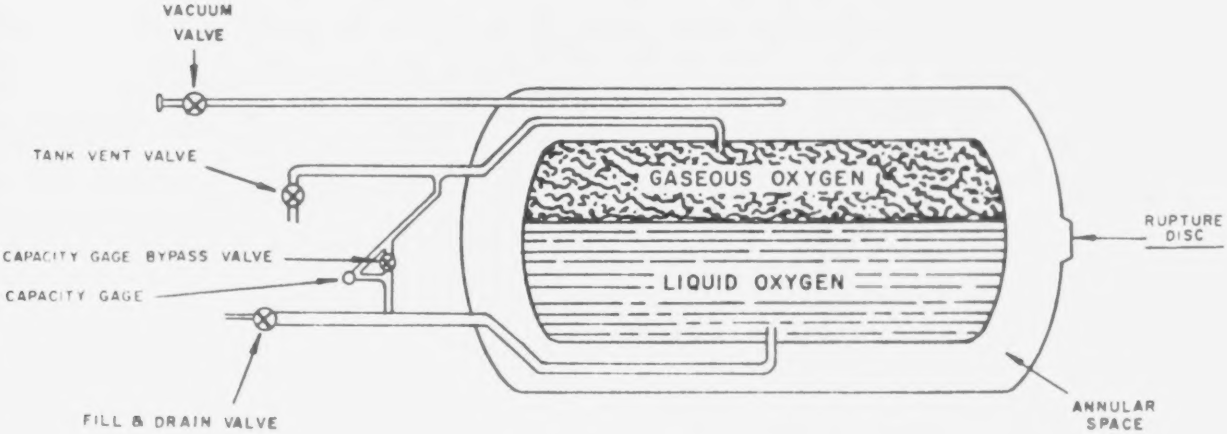

VACUUM VALVE
TANK VENT VALVE
GASEOUS OXYGEN
RUPTURE DISC
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
LIQUID OXYGEN
FILL & DRAIN VALVE
ANNULAR SPACE

Figure 4.

BUILD-UP VALVE

LOX tanks do not have pumps to aid in the rapid transfer of LOX. So some other way must be used to move the liquid. The other way is pressure. As you already know, if the tank vent is closed, pressure will start to build in the tank. But this is a slow process. To speed this process, a pressure buildup valve and coil are attached to the fill and drain line. When the pressure buildup valve is opened (see figure) LOX will flow through the pressure buildup coil (heat exchanger) where it is changed to a gas. From the heat exchanger, the gas follows the pipe which joins the tank vent pipe (remember the tank vent is closed). The gas will then flow back into the gaseous portion of the tank and will apply added pressure to the liquid which allows a more rapid transfer of LOX. This valve will remain closed except when building up pressure in the tank. The pressure buildup valve will be colored coded white and may be letter coded "D".

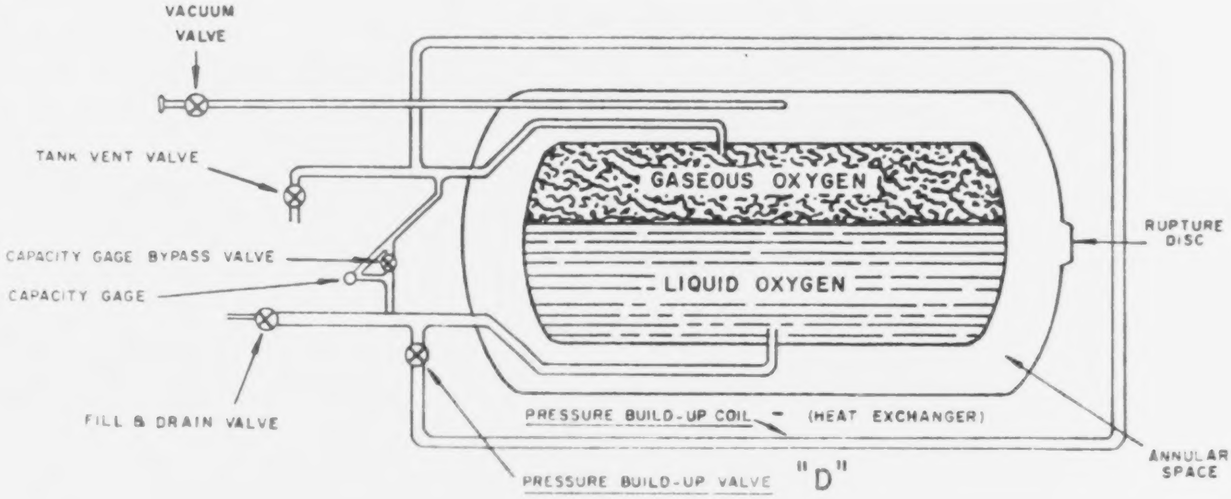

VACUUM VALVE
TANK VENT VALVE
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
FILL & DRAIN VALVE
GASEOUS OXYGEN
LIQUID OXYGEN
RUPTURE DISC
PRESSURE BUILD-UP COIL - (HEAT EXCHANGER)
ANNULAR SPACE
PRESSURE BUILD-UP VALVE "D"

Figure 5.

PRESSURE GAGE

Just above the point that the pressure buildup coil joins the tank vent line is a direct reading gage (Pressure Gage). This is used to tell how much pressure is built up within the vapor portion of the inner tank.

TANK PRESSURE RELIEF VALVE

Located just above the pressure gage in the pressure build up line is a protective device, the Tank Pressure Relief Valve. This valve will relieve excessive pressure in the inner tank. (Depending on the type of tank the valve will operate either manually or automatically.) See figure below.

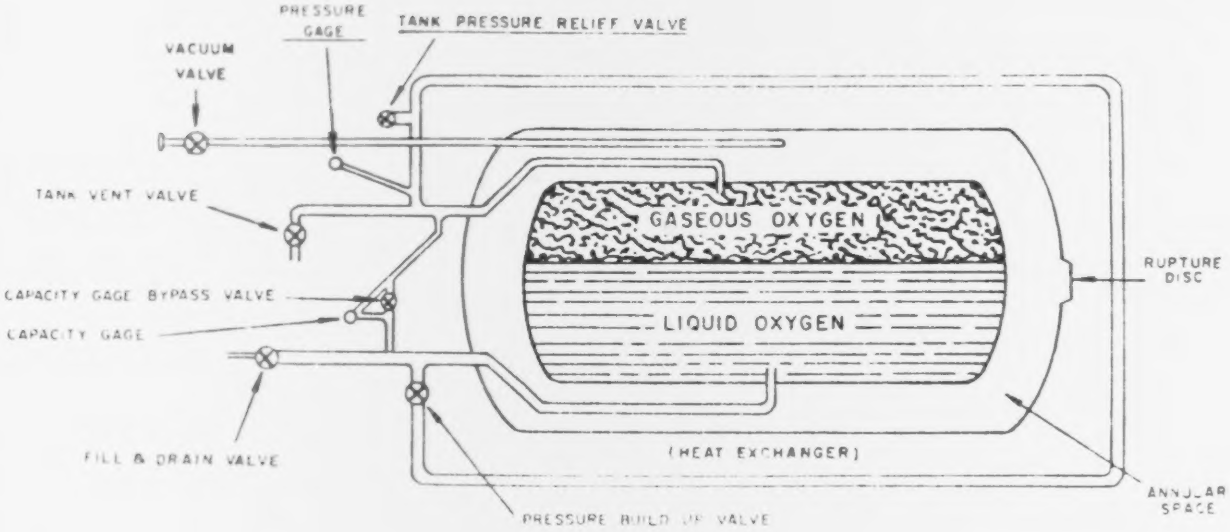

PRESSURE GAGE
TANK PRESSURE RELIEF VALVE
VACUUM VALVE
TANK VENT VALVE
GASEOUS OXYGEN
RUPTURE DISC
CAPACITY GAGE BYPASS VALVE
CAPACITY GAGE
LIQUID OXYGEN
FILL & DRAIN VALVE
(HEAT EXCHANGER)
ANNULAR SPACE
PRESSURE BUILD UP VALVE

Figure 6.

TRANSFER HOSE

Before we talk about the next relief valve, let's learn about the unit it protects. This is the LOX cart transfer hose.

The transfer hose does just what its name implies--it transfers liquid oxygen through the hose from one container to another. The hose, like the LOX cart, has to be insulated to prevent the liquid oxygen from turning into a gas. It also prevents the operator from frostbite due to the extreme temperature of LOX.

The hose is made up of 3 parts -- (Ref to figure 7), the inner hose, the corrugated hose and the scuff guard. The inner hose, is the part that the liquid oxygen flows through. The hose is made of a special rubber and the diameter is about the size of a dime. The corrugated hose is made of a metal braid and acts as an insulator. The last part of the hose is the scuff guard. The guard is used to protect the corrugated hose from damage. The scuff guard can be removed and replaced but the inner hose and the corrugated hose are a combined unit.

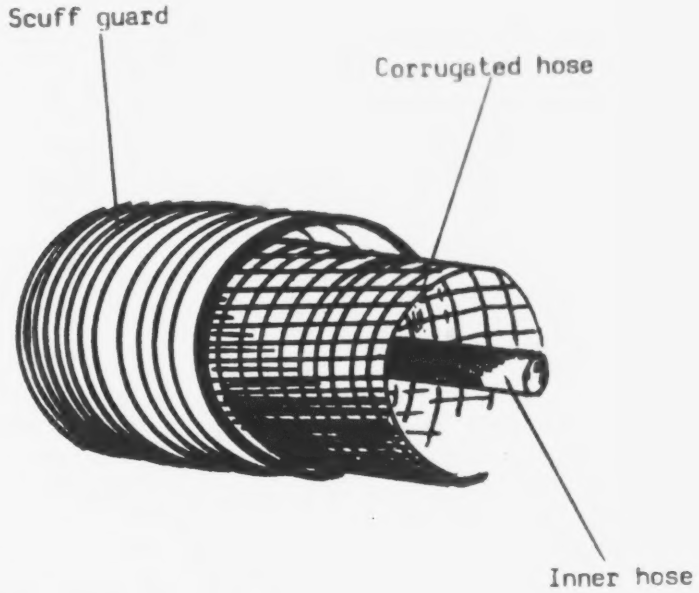
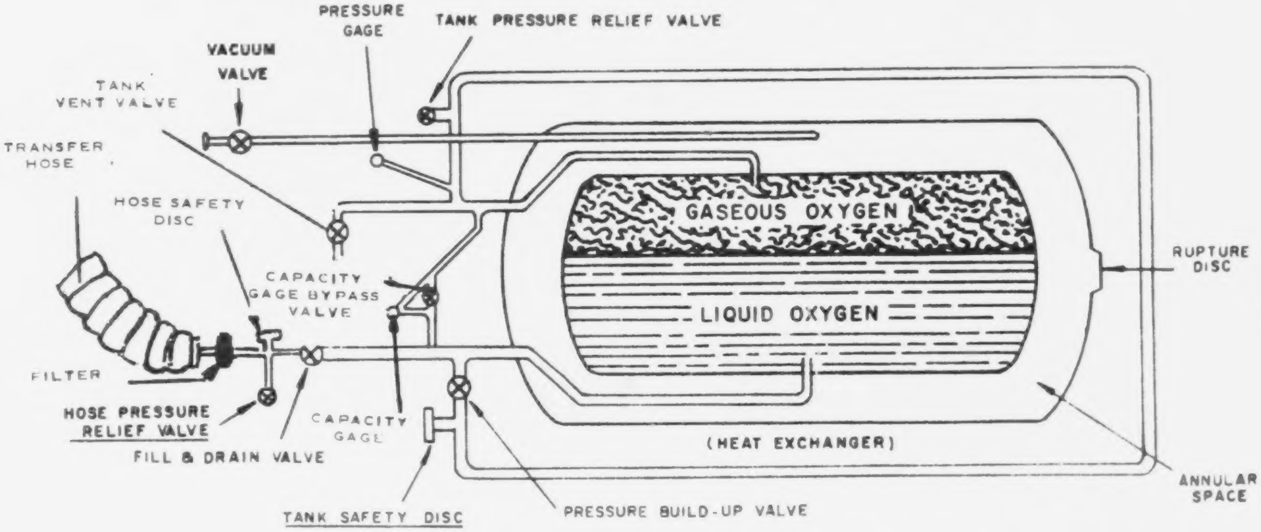


Figure 7. Transfer Hose.

HOSE PRESSURE RELIEF VALVE

The next relief valve is located in the fill and drain line. This is the Hose Pressure Relief Valve. This relieves excessive pressure in the transfer hose and, depending on the type of tank, will be manually or automatically operated. There are two more safety devices, one located in the pressure buildup line and one in the fill and drain line. These are safety discs. If for example, the hose pressure relief valve or tank pressure relief valve were frozen in the closed position, these discs (Hose Safety Disc and Tank Safety Disc) are designed to blow out if the pressure in the hose or tank continued to rise.

The last item is of the Filter located in the fill and drain line. The filter is the metal porous type. This unit, as the name implies, filters LOX.


PRESSURE GAGE
TANK PRESSURE RELIEF VALVE
VACUUM VALVE
TANK VENT VALVE
TRANSFER HOSE
HOSE SAFETY DISC
CAPACITY GAGE BYPASS VALVE
GASEOUS OXYGEN
LIQUID OXYGEN
RUPTURE DISC
FILTER
HOSE PRESSURE RELIEF VALVE
FILL & DRAIN VALVE
CAPACITY GAGE
(HEAT EXCHANGER)
ANNULAR SPACE
TANK SAFETY DISC
PRESSURE BUILD-UP VALVE

Using the diagram, enter the number that correctly identifies the components that make up a liquid oxygen facility. If you are not sure of the answers go back and review the information.

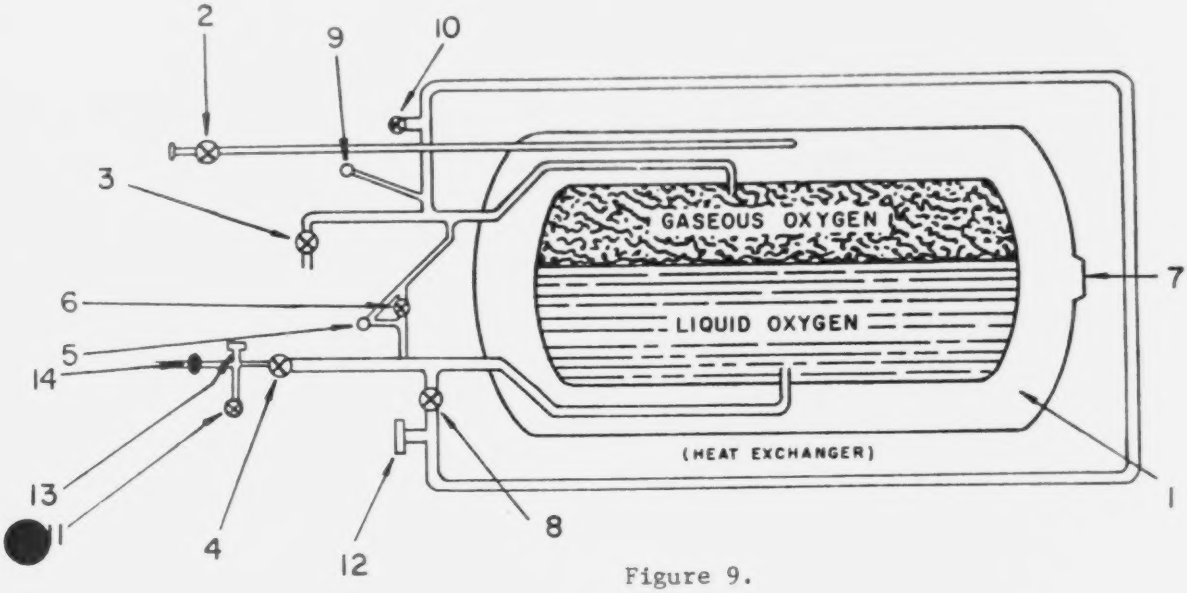

2
9
10
3
GASEOUS OXYGEN
7
6
LIQUID OXYGEN
5
14
(HEAT EXCHANGER)
13
11
4
12
8
1

Figure 9.

a. _____Vacuum valve

b. _____Pressure buildup valve

c. _____Tank safety disc

d. _____Annular space

e. _____Hose pressure relief valve

f. _____Rupture disc

g. _____Hose safety disc

h. _____Tank vent valve

i. _____Tank pressure relief valve

j. _____Fill and drain valve

k. _____Pressure gage

l. _____Capacity gage

m. _____Capacity gage bypass valve

n. _____Filter

SYSTEM OPERATION

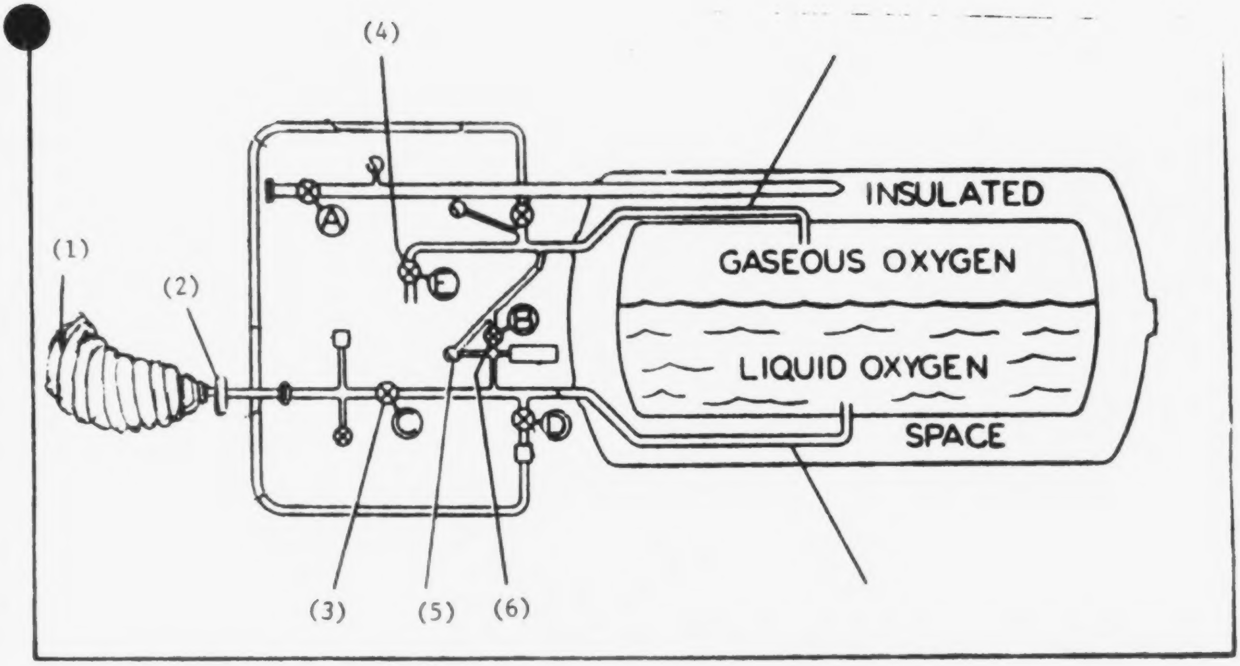
Now we will talk about the complete operation of the cryotainer.

For you to learn the system's operation you must know how to fill the cryotainer. The large storage units used at most bases are filled from a tractor trailer truck just like the ones used to service gas stations with gasoline. Some bases produce their oxygen in a plant type operation and the liquid is pushed right into the tank from the plant, (refer to figure 10). First you must connect the transfer hose (1) to the unit you are going to fill. The connection is made at the fill and drain port (2). Next open the fill-drain valve (3). Now open the vent valve (4), all other valves should be closed. The cryotainer is ready to receive liquid at this time. When liquid is pushed into the cryotainer, it flows from the storage container of the servicing truck through the transfer hose (1) and into the plumbing of the cryotainer. The liquid then flows through the fill-drain valve. After liquid passes through the fill-drain valve it will enter the inner tank of the cryotainer. You will know when the container is full when there is a steady stream of liquid flowing out of the vent valve.

After the receiving tank is full, the transfer hose must be disconnected and stored. Also, a quantity reading will be taken.

Located on the pressure line that connects the vent pipe and the transfer pipe is a capacity gage (5). As the name states, this gage shows the amount of liquid oxygen within the inner tank. This gage is sensitive to pressure and it can be damaged by pressure surges. Therefore, the gage is offset from the pressure line and is protected by a capacity gage bypass valve (6) located in the pressure line.

The valve located in the pressure line is a safety device that protects the capacity gage. This valve is normally open, allowing pressure to "bypass" (go around) the capacity gage. The bypass valve should be closed only when you need to obtain the amount of LOX in the tank. As soon as you have obtained the amount of LOX within the tank, the bypass valve should be opened again.



1. Transfer Hose
2. Fill-Drain Port
3. Fill-Drain Valve C
4. Vent Valve E
5. Capacity Gage
6. Capacity Gage Valve B

Figure 10. Liquid Oxygen Cryotainer.

Select the correct answer for the following questions.

1. The first step when filling a cryotainer is to

   a. start the pump.

   b. connect the transfer hose.

   c. open the fill and drain line.

   d. build up pressure in the receiving container.

2. You know that the tank is full when

   a. the capacity gage reads full.

   b. liquid starts to come out of the vent valve.

   c. the capacity gage reads 5 gallons over the full mark.

   d. liquid flows from the vent valve in a steady stream.

3. When filling a cryotainer, the vent valve should be closed.

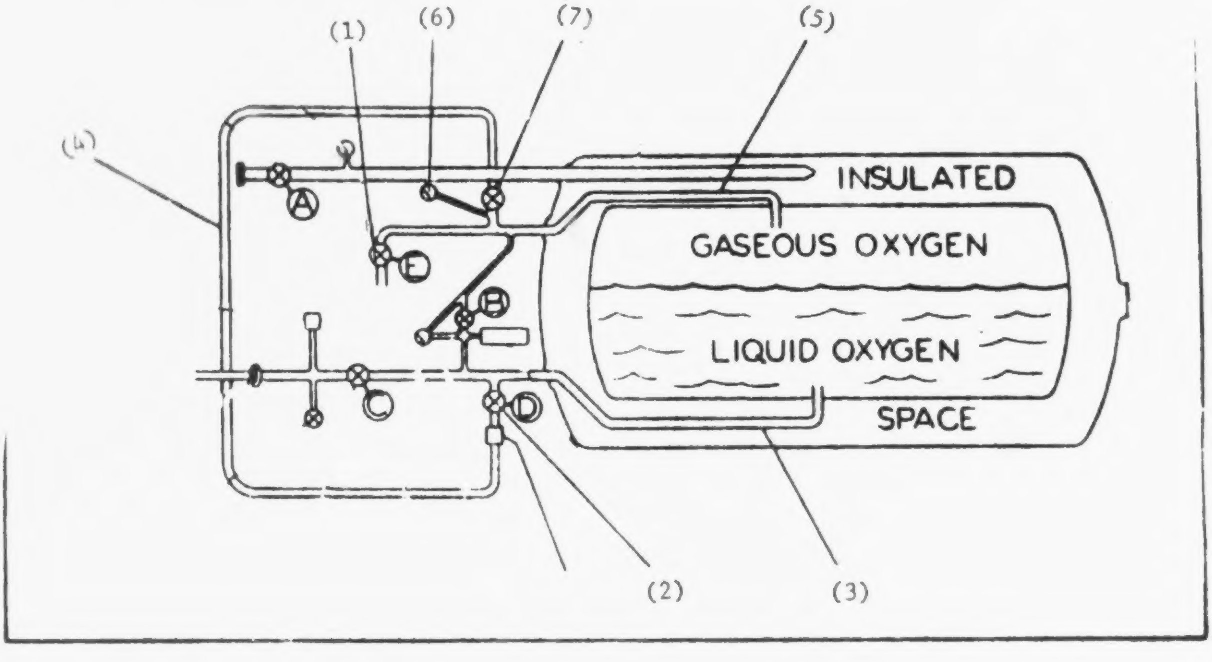
   a. True.

   b. False.

BUILD-UP PHASE

Now that you have learned how to fill a cryotainer, the next phase of operation we will discuss is the buildup phase. The first thing you should do is to close the vent valve (1). The vent valve is closed so that pressure will not be vented out of the cart. The next thing to do is to open the pressure buildup valve (2). When the buildup valve is open, liquid oxygen is drawn from the inner container through the fill-drain line (3) then into the buildup valve (2). The liquid now goes into the buildup coil (4), where the liquid will take on heat and turn into a gas. The gas will travel through the vent line (5) into the top of the tank. At this point, the gas on the top of the inner tank is pushing down on the liquid. During this phase of the buildup operation, it is important that you continually watch the pressure gage (6). Normal operating pressure is 30+ or -5 psig. When you have reached the operating pressure, close the pressure buildup valve (2). This will stop the liquid from being changed into a gas and prevent the pressure from rising any higher. If at any time the pressure should rise above 30+ or -5 psig, insure that the buildup valve is closed (2), then slowly open the vent valve (1). This will vent gas out of the tank. When the pressure is back within the 30+ or -5 psig operating range, close the vent valve.

If pressure was to raise to 50+ or -5 psig the tank pressure relief valve (7) would open and vent pressure automatically. If the pressure relief valve (7) malfunctioned and didn't relieve the pressure, the safety disc would rupture and relieve the pressure in the tank.



1. Vent Valve E
2. Pressure Buildup Valve D
3. Fill-Drain Line
4. Pressure Buildup Coil
5. Vent Line
6. Pressure Gage
7. Pressure Relief Valve 1

Figure 11. Liquid Oxygen Cryotainer.

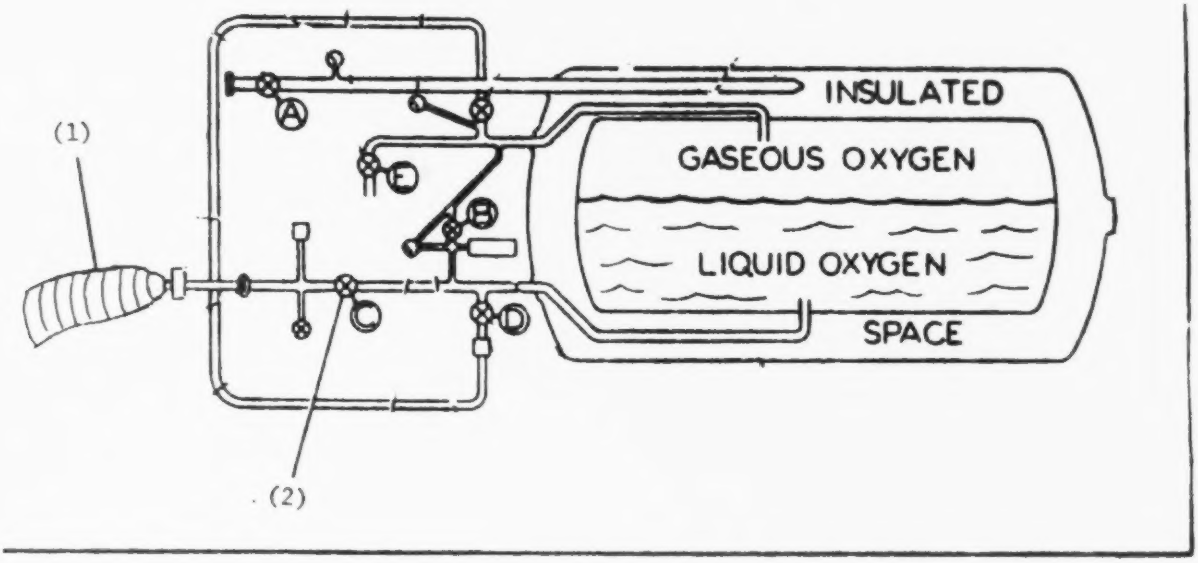
Select the correct answer to the following questions.

1. The first thing you should do in the buildup stage is
   - a. open the vent valve.
   - b. close the vent valve.
   - c. purge the buildup coil.
   - d. open the bypass valve.
2. Operating pressures should not exceed
   - a. 25 psi.
   - b. 30 psi.
   - c. 35 psi.
   - d. 40 psi.
3. After reaching the operating pressure you should
   - a. open the vent valve.
   - b. close the bypass valve.
   - c. close the buildup valve.
   - d. disconnect the transfer hose.
4. What would happen if the pressure of a cryotainer reached 40 psi?
   - a. The inner tank rupture disc would blow.
   - b. Nothing - 40 psi is the normal operating pressure.
   - c. The tank pressure relief valve would relieve excess pressure.
   - d. Nothing - the pressure relief valve relieves at 50 ± 5 psi.

TRANSFER OPERATION

Now let's talk about the transfer operation. The first step in transferring LOX, is to make sure that the LOX tank from which you will transfer (source tank) has enough LOX for the transfer operation. Also insure that you have built up enough pressure in the source tank for transferring LOX. This procedure was talked about in the last frame. Now connect one end of the transfer hose (1) to the fill-drain line on the source tank. Remove the dust cover from the other end of the transfer hose. Place the open end of the transfer hose into a drip pan. Slightly open the fill and drain valve (2) on the source tank. Allow a small amount of liquid to go into the hose, to purge any dust or dirt out of the hose. Close the fill and drain valve on the storage tank.

Now you can remove the dust cover from the fill and drain line on the receiving tank. Connect the transfer hose to the receiving tank. Place all valves on the receiving tank in the same positions described under the fill phase frame.



1. Transfer Hose
2. Fill-Drain Valve C

Figure 12.

1. The first step in transferring LOX is to
    a. build up pressure.
    b. clear out the transfer hose.
    c. make sure you have enough LOX.
    d. remove the dust cap from the transfer hose.
2. What is the position of the valves when transferring LOX?
    a. Vent valve open, buildup valve open, transfer valve open.
    b. Vent valve closed, buildup valve open, transfer valve closed.
    c. Vent valve closed, buildup valve closed, transfer valve closed.
    d. Vent valve closed, buildup valve closed, transfer valve open.

At this point you should be familiar with the construction and operation of a cryotainer system. It is very important for you to know all the components and how they work. If you are unsure of any information given in this PT, go back and review the frames covering the information. If you still have questions, ask your instructor for help. This concludes the PT on the construction and operation of a cryotainer. See your instructor at this time.

PROGRAMMED TEXT
C3ABR42331-PT-405A

Technical Training

Aircraft Environmental Systems Mechanic

RECHARGING EQUIPMENT FOR AND MAINTENANCE OF LIFE RAFT CYLINDERS

20 October 1982

CHANUTE TECHANICAL TRAINING CENTER (ATC)
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OBJECTIVES

1. Relate four of five components of the life raft recharging equipment to their use.

2. Specify the safety precautions relative to charging/discharging life raft cylinders with 100% accuracy.

INSTRUCTIONS

This programmed text presents material in small steps called frames. After each frame you will find questions. Read the information given and respond by entering the correct response on your response sheet. The answers to each frame are at the top of the next page. Anytime you respond incorrectly, reread the frame to get the information straight in your mind. Some frames do not require a response. When you have finished reading a frame that does not require a response, go directly to the next frame.

Supersedes 3ABR42331-PT-405A, 23 February 1981.
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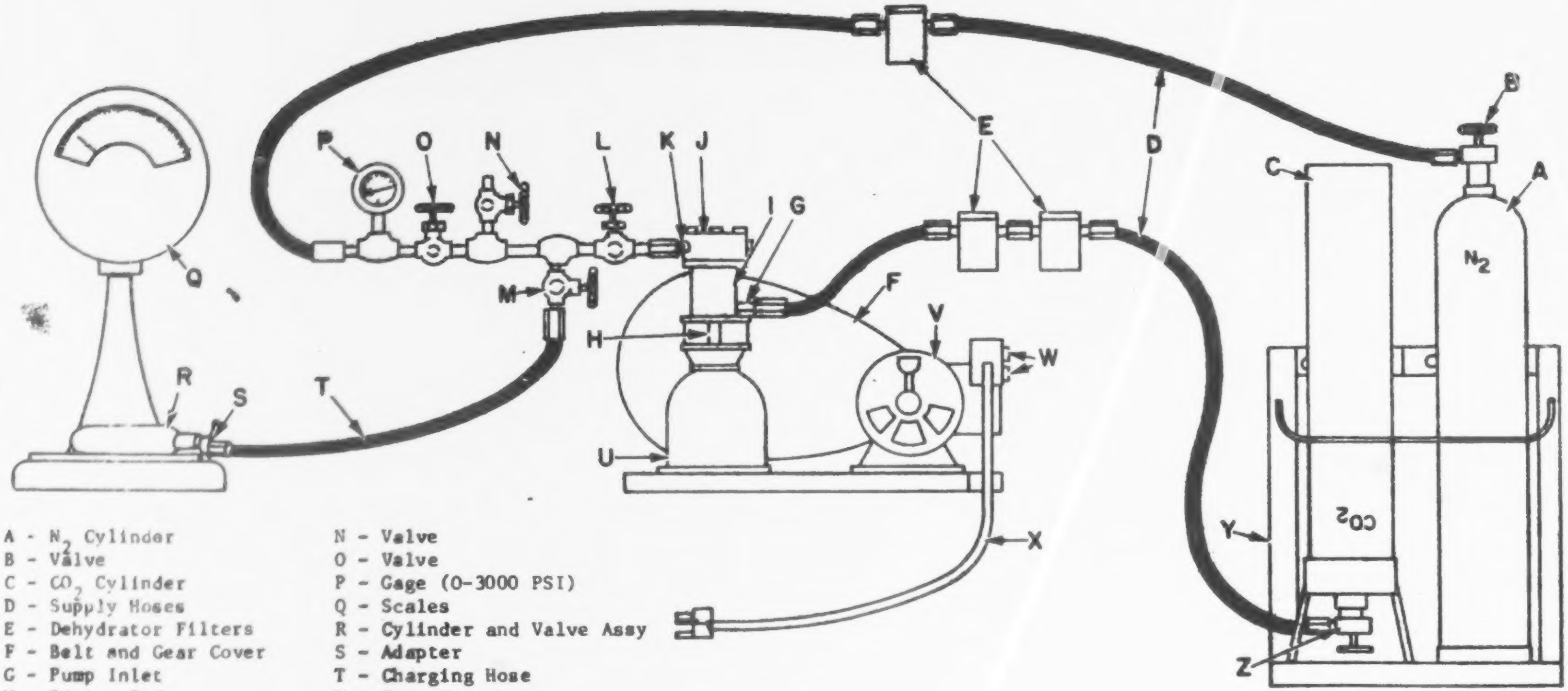
Frame 1

Figure 1 shows a typical equipment setup for charging one-man and multiplace life raft inflation cylinders. It consists of a motor driven pump, a scale, one CO_2 cylinder, one N_2 cylinder (both cylinders are placed on the same stand), dehydrator filters, a gage, shut-off valves, assorted metal hoses and adaptors. This is just a basic setup. Other variations may be used, but all will have much the same equipment as shown in figure 1.

NO RESPONSE REQUIRED



A - N_2 Cylinder
B - Valve
C - CO_2 Cylinder
D - Supply Hoses
E - Dehydrator Filters
F - Belt and Gear Cover
G - Pump Inlet
H - Piston Rod
I - Pump Cylinder
J - Cylinder Head
K - Pump Outlet
L - Valve
M - Valve

N - Valve
O - Valve
P - Gage (0-3000 PSI)
Q - Scales
R - Cylinder and Valve Assy
S - Adapter
T - Charging Hose
U - Pump Cranckcase
V - Motor
W - Start/Stop Buttons
X - Power Cord
Y - Frame
Z - Valve

Figure 1.

Answers to Frame 1: NO RESPONSE REQUIRED

Frame 2

The pump drive motor may be a three phase, 220 VAC unit or a single phase, 115 VAC unit of sufficient horsepower to drive the charging pump. Power is transferred from the motor to the pump by a drive belt. The pump is a ram type unit that will pump only liquid, it will not pump gas of any kind. Since the pump will pump only liquid, it is important to keep the CO_2 as cool as possible in order that more liquid will be available for cylinder charging. The pumping equipment is protected from damage by a rupture disc or by a spring-loaded relief valve that will relieve the system if the pressure becomes excessively high. The maximum pressure for a specific pumping unit may be found in the applicable technical order.

Complete the following statements by writing in the words from the frame above.

a. One requirement for the pump drive motor, regardless of its power requirement, is that it have sufficient __________________ to drive the ______________.

b. CO_2, in the storage cylinder, must be kept as ____________ as possible because the pump will not transfer ___________ of any kind.

c. If charging pressure should become excessively high, the pumping equipment is protected from damage by a ______________ disc or a spring-loaded _________________ valve.

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Answers to Frame 2: a. horsepower, pump b. cool, gas
c. rupture, relief

Frame 3

Four shutoff valves are located on the charging control panel to control the flow of liquid and gas to the cylinder being charged. Valve 0 controls the flow of N_2 to the charging hose from the supply cylinder; valve L controls the flow of CO_2 from the charging pump; valve M is the shutoff valve to the charging hose for both liquid and gas. Valve N is a dump valve which is used to dump pressure from the supply hoses after the cylinder has been charged and valves L and 0 have been closed.

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Mark the following statements with a T for True or an F for False.

_____1. The purpose of the shutoff valves is to control the flow of liquid and gas that are used to charge the inflation cylinder.

_____2. The flow of liquid or gas into the charging hose is controlled by valve M.

_____3. After the cylinder has been charged, pressure is dumped from the supply hoses by opening valve Z.

Answers to Frame 3: __T__ 1. __T__ 2. __F__ 3.

Frame 4

Dehydrator filters E are installed in both the liquid and gas supply hoses D from the supply cylinders A and C to remove any moisture from these agents before they are put into the cylinder R. One filter E is installed in the N_2 supply hose and two are installed in the CO_2 supply hose, in series. The hoses, fittings, adaptors and shutoff valves are of the brass, high pressure type. The adaptors S are used to connect the charging hose to the cylinder R that is to be charged. A gage P is installed in the N_2 supply hose, on the control panel, as a means of determining the quantity of N_2 supply. The scale Q used to weigh the cylinder assembly and the N_2 and CO_2 charges must be graduated to read in hundredths of a pound.

Complete the following statements by writing in the words from the frame above.

a. Dehydrator filters are installed in the ____________ and ____________ supply hoses to remove ____________ from these agents before they are put into the cylinder.

b. ____________ filters are installed in ____________ in the CO_2 supply hose and one is installed in the ____________ supply hose.

c. A ____________ is installed in the N_2 supply hose as a means of determining the quantity of the ____________ supply.

d. The scale used to weigh the cylinder and the ____________ and ____________ charges must be graduated to read in ____________ of a pound.

e. The hoses, fittings, adaptors and ________________________ valves are of the brass, ____________ pressure type.

Answers to Frame 4: a. N_2, CO_2, moisture b. Two, series, N_2
c. gage, N_2 d. N_2, CO_2, hundredths
e. shutoff, high

Frame 5

The source of supply for the CO_2 is a standard ICC (Interstate Commerce Commission) shipping and storage cylinder C (N_2 comes in a similar cylinder). The CO_2 cylinder, when fully charged, contains 50 pounds of CO_2. At 70°F, 12 pounds of this weight will be gas and 38 pounds will be liquid. The proportion of liquid will be greater at lower temperatures. Before installing a new cylinder of CO_2, determine if the cylinder has a syphon tube. If the cylinder has a syphon tube, it must be installed with the valve up so that the liquid may be drawn off before the gas. If the cylinder does not have a syphon tube, it must be installed with the valve down so that the liquid may be drawn first. The N_2 cylinder A is always installed with the valve up. Both cylinders must be firmly secured to keep them from falling over.

Complete the following statements by writing in the words from the frame above.

a. The shipping and storage CO_2 cylinder contains ____________ pounds of ________________ when fully charged.

b. At 70°F, a fully charged CO_2 shipping and storage cylinder will contain ______________ pounds of liquid and ____________ pounds of gas.

c. At 0°F, the weight of the liquid CO_2 in the cylinder will be _________________ (greater, less) than the weight of the liquid CO_2 at 70°F.

d. If the CO_2 cylinder has a syphon ______________, it must be installed with the valve ___________________.

e. The N_2 cylinder is always installed with the valve ____________.

Answers to Frame 5: a. 50, CO_2 b. 38, 12 c. greater
d. tube, up e. up

Frame 6

Before the charging hose T is attached to the cylinder, it must be purged of air to insure that no moisture is injected into the cylinder R along with the liquid or gas. To purge the charging hose, the N_2 valve O, the charging hose shutoff valve M and the N_2 cylinder, shutoff valve B must be opened to allow N_2 to flow through the charging hose. After the charging hose has been purged, it is immediately attached to the cylinder R to be charged. This prevents moisture laden air from reentering the charging hose to be injected into the cylinder. The cylinder and valve assembly, with the charging hose attached, is placed on the scale Q to obtain its empty weight reading. This is used as a reference weight to determine what the full weight indication on the scale should be when the specified pounds of N_2 and CO_2 are added during the charging operation. The full weight will be the empty weight plus the specified pounds of N_2 and CO_2 to be added.

Mark the following statement with a T for True or an F for False.

_____1. The charging hose must be filled with air before it is attached to the cylinder.

_____2. Purging the charging hose insures that no oxygen is injected into the cylinder.

_____3. After the charging hose has been purged, it is immediately attached to the pump.

_____4. The cylinder and valve assembly, with the charging hose attached, is placed on the scale to obtain a reference weight.

Answers to Frame 6: _F_ 1. _F_ 2. _F_ 3. _T_ 4.

Frame 7

The charging equipment does not require a great amount of maintenance. Before using it, give it a visual inspection for obvious defects and cleanliness. Scheduled inspections, lubrication intervals and types of lubricants are given in the applicable technical order. The TO also gives instructions for repair and overhaul of this equipment. The more common troubles encountered with this equipment are also listed in the TO along with the remedies for them.

Complete the following statements by writing in the words from the frame above.

a. Before operating the charging equipment, give it a ____________ inspection for _______________ defects and ___________________.

b. Requirements for inspections, lubrication intervals and types of _________________________ required are given in the applicable _______________ ____________.

c. Most common ___________ and the ___________ for them are given in the TO along with instructions for _____________ and overhaul.

Answers to Frame 7: a. visual, obvious, cleanliness
b. lubricants, TO c. troubles, remedies, repair

Frame 8

All cylinders returned for charging are subjected to a very thorough inspection to insure that they are free from defects and that they are protected from exposure to corrosion. The specific inspection requirements are given in the applicable technical order. Any cylinder that fails to meet these inspection requirements is tagged as reparable and set aside for further inspection and repair. Only those cylinders having no defects may be recharged.

Mark the following statements with a T for True or an F for False.

_____a. Before a cylinder is recharged, it is inspected to insure that it is free from defects and protected from exposure to corrosion.

_____b. Cylinders that fail to meet inspection requirements are tagged as serviceable and set aside for further use.

_____c. Cylinders that have no defects may be recharged.

Answers to Frame 8: __T__ a. __F__ b. __T__ c.

Frame 9

General overhaul of multiplace cylinders includes disassembly, cleaning, inspection, repair and reassembly as directed by the applicable technical order. The cylinders are hydrostatically tested every five (5) years (quinquennial test) at 5/3 the cylinder working pressure (Example: 5/3 x 2100 psi = 3500 psi). Cylinders having an outside diameter of less than two inches and a length of less than two feet are exempt from the quinquennial test.

Complete the following statements by writing in the words from the frame above.

a. A hydrostatic or quinquennial test is not required on the one-man cylinder because it is less than ____________ inches in diameter and __________ than ___________ feet in length.

b. The hydrostatic or quinquennial test is performed on cylinders every __________ years at __________ the cylinder working pressure.

c. General overhaul of the multiplace cylinder includes disassembly, cleaning, ____________, ____________ and reassembly.

d. A cylinder having a working pressure of 2400 psi would be hydrostatically tested using ___________ psi.

Answers to Frame 9: a. two, less, two b. 5, 5/3
c. inspection, repair d. 4000

Frame 10

The hydrostatic or quinquennial test indicates the permanent volumetric expansion of the cylinder. The test is conducted by placing the cylinder in a water jacket and measuring the amount of water displaced when the cylinder is pressurized. Water is forced into the cylinder under pressure to meet the requirements indicated in the formula given in frame 9 in order to stretch the cylinder. Internal water pressure must be maintained for not less than 30 seconds. After the water pressure has been released from the cylinder, the remaining permanent volumetric expansion of the cylinder must not exceed 10% of the total volumetric expansion which occurred during pressurization. The date of the latest hydrostatic test is stamped on the cylinder below the previous date mark. Cylinders that fail the hydrostatic test are made unserviceable by damaging the threads and tagging the cylinder CONDEMNED.

Mark the following statements with a T for True or an F for False.

_____a. Permanent volumetric expansion is shown by the hydrostatic test.

_____b. The permanent volumetric expansion remaining after pressure has been released from the cylinder must not exceed 15 percent of the total volumetric expansion which occurred during pressurization.

_____c. Cylinders that fail the hydrostatic test are made unserviceable by damaging the threads and tagging the cylinder as serviceable.

_____d. The date of the hydrostatic test is painted on the cylinder below the previous date.

Answers to Frame 10: T a. F b. F c. F d.

Frame 11

Before the charging operation is begun, each cylinder must be weighed individually and the weight checked against the weight stenciled on the cylinder. These two weights should be the same. If they are not the same, the cylinder must be restenciled with the weight down on the scale. Different, information is required on the one-man than on the multiplace cylinders, so check the applicable TO before you cut the stencil and start spraying paint. For your information, this information is also included in frame 19 of this text.

Mark the following statements with a T for True or an F for False.

_____a. After the cylinder has been inspected, it must be weighed and the date checked against the date stenciled on the cylinder.

_____b. If the two weights are not the same, the cylinder must be restenciled with the weight shown on the scale.

_____c. The information to be stenciled on the one-man cylinder is different from the information to be stenciled on the multiplace cylinder.

Answers to Frame 11: ___F___a. ___T___b. ___T___c.

Frame 12

Remember from a previous text, that at cold temperatures, CO_2 gas changes to a liquid. Consequently, at temperatures below 0°F, the CO_2 pressure in the cylinder will drop considerably--possibly to the point where the CO_2 will not discharge fast enough to effectively inflate the life raft. For this reason, multiplace cylinders are given a charge of dry nitrogen, N_2, to serve as a propellant for the CO_2 charge. Nitrogen pressure will remain high at temperatures as low as -65°F. The amount of nitrogen to be added to the cylinder, by weight, may be found in the applicable technical order. This information is also included as a part of frame 13 of this text.

Complete the following statements by writing in the words from the frame above.

a. At low temperatures, CO_2 tends to ____________________, therefore, at 0°F, the liquid content of the cylinder would be ____________________ (greater, less) than at a temperature of 80°F.

b. At temperatures below 0°F, CO_2 pressure in the cylinder will _______________ considerably and may not effectively ______________ the life raft.

c. For cold weather operation, _____________ N_2 is added to the cylinder to act as a _________________ for the CO_2 charge.

d. The pressure of _______________ will remain high at temperatures as low as ___________°F.

Answers to Frame 12: a. liquefy, greater b. drop, inflate
c. dry, propellant d. N_2, -65

Frame 13

When charging the multiplace cylinder, N_2 is first injected into the cylinder as directed in the applicable TO. After the specified amount of N_2, by weight, has been added to the cylinder, the CO_2, is added. The N_2 and CO_2 charges have specified weights which must be within the weight limits shown in the technical order. The amount of N_2 added to the cylinder depends on the capacity of the cylinder in cubic inches. Charging procedures for the one-man cylinder are the same as for the multiplace cylinder, except that the N_2 charge is left out. When charging any inflation cylinder, protective clothing consisting of gloves and a face mask or goggles must be worn.

Mark the following statements with a T for True or an F for False.

_____a. The amount of N_2 added to a cylinder depends on the capacity of the cylinder in cubic inches.

_____b. Charging procedures for the one man cylinder are the same as for the multiplace cylinder, except that the N_2 charge is left out of the one-man cylinder.

_____c. When charging any cylinder, a face mask or goggles and rubber apron must be worn.

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Answers to Frame 13: __T__a. __T__b. __F__c.

Frame 14

The CO_2 used to charge all life raft cylinders must conform to Grade B, Type I or II of Specification BB-C-101. All CO_2 used to charge life raft cylinders is passed through two dehydrator filters connected into the supply hose in series before it is injected into the cylinder. The dehydrator filter cartridges, to insure continued drying action, must be replaced whenever 250 pounds of CO_2 have passed through them.

Complete the following statements by writing in the words from the frame above.

All CO_2 used to charge ________ _________ cylinders is passed through ____________ dehydrator filters connected into the supply hose in _______________ before it is injected into the cylinder.

b. The CO_2 used to inflate life raft cylinders is passed through _________________ dehydrator filters to insure that there is no _________ in the CO_2 when it is injected into the cylinder.

To insure the continued effectiveness of the ______________ filters, they must be replaced after ____________ pounds of ____________ have been passed through them.

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Answers to Frame 14: a. life raft, two, series b. two, moisture
c. dehydrator, 250, CO_2

Frame 15

As mentioned in a previous frame, recharging procedures for the multiplace and one-man cylinders are generally the same. There are some small differences, one of which was the omission of the N_2 charge from the one-man cylinder. Another difference is based upon the construction of the valve assembly. On the one-man cylinder, you will find it necessary to open the valve before you can charge the cylinder with CO_2. The multiplace assembly may be charged without rotating the sheave to open the valve. This is due to the construction of the valve assembly, which acts as a check valve. Just hook it up and its ready to receive the charge.

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Complete the following statements by writing in the words from the frame above.

a. When charging the one-man cylinder the __________ charge is

_________ ____________.

b. To charge the multiplace cylinder, it is not necessary to open the ______________ because the internal construction of the unit acts as a ______________ valve.

c. The valve assembly on the _______ - ________ cylinder must be ______________ before it will accept a charge.

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Answers to Frame 15: a. N_2, left out b. valve, check
c. one-man, open

Frame 16

It may require some practice on your part before you will be able to charge a cylinder and get it within the tolerances specified in the technical order. The tendency is to overcharge the cylinder. If the cylinder is overcharged, the excess charge must be removed. Check the technical order for "bleed off" procedures and don't forget to install the diffuser plug before you "bleed off" the excess. By installing the diffuser plug, you are protecting yourself from injury from the jet of high pressure CO_2 which will be released from the cylinder when you open the valve. Don't forget your protective equipment, this is a must throughout the charging procedure. In case you've forgotten what the protective equipment is, put on gloves and face mask or goggles during all charging operations. Remember that CO_2 absorbs a great amount of heat during the evaporation process and can cause severe frostbite to the unwary or careless individual.

Complete the following statements by writing in the words from the frame above.

a. The diffuser plug is installed in the cylinder charge/discharge port to prevent __________ from the jet of escaping high pressure ________________.

b. Caution must be exercised during the bleed off operation because CO_2 absorbs a great amount of ___________ and can cause severe ________________.

c. If a cylinder is overcharged, the excess must be ____________ off in accordance with procedures outlined in the applicable ___________ ________________.

d. Protective equipment consisting of _____________ and a _________ ____________ or ______________ must be worn during all charging operations.

Answers to Frame 16: a. injury, CO_2 b. heat, frostbite
c. bled, technical order d. gloves, face mask, goggles

Frame 17

After charging the cylinder, the charging hose T must be disconnected to permit the attachment of another cylinder to the charging equipment. First, insure that the N_2 and CO_2 control valves are closed. Open valve N to bleed off or DUMP pressure from the supply hoses. The charging hose may be cleared at this time by opening valve M and releasing the pressure through valve N. First, insure that the valve on the inflation cylinders is in the closed position. O.K., now slowly loosen the adaptors between the charging hose and the cylinder, just in case there's still some pressure and liquid left in the charging hose. After all pressure has been released from the lines, and the cylinder disconnected, close all valves to keep moisture from entering the system.

Complete the following statements by writing in the words from the frame above.

a. After the cylinder has been charged and disconnected from the charging hose, the charging hose must be plugged and all valves must be ______________ to prevent ______________ from entering the system.

b. The charging unit supply hoses are depressurized by ______________ valve ______________.

c. When disconnecting the charging hose from the cylinder, the adaptor should be loosened ______________ as a safety precaution.

d. Before opening valve N, insure that the ______________ valve and the ______________ valve have been ______________.

Answers to Frame 17: a. closed, moisture b. opening, N
c. slowly d. N_2, CO_2, closed

Frame 18

After the fully charged cylinder has been removed from the charging unit, two leakage checks must be performed. The first is a water tank check performed under reflected light. The cylinder is submerged in a tank of water for 30 minutes and observed for bubbles rising to the surface of the water. If there are indications of leakage during this test, the point of leakage must be located and corrected. The cylinder must then be recharged and another leakage test performed. If no leakage is evident, the cylinder is stored for a period of 24 hours, as specified in the applicable TO. At the end of the 24 hour storage period the cylinder is reweighed. The allowable weight loss for the one-man cylinder is 1/100th of the weight of the CO_2 charge immediately after charging. For the multiplace cylinder the allowable weight loss is 1/100th of a pound in 24 hours. When both of these checks have been satisfied, the cylinder is considered to be serviceable.

Mark the following statements with a T for True or an F for False.

_____a. Leakage from a recharged cylinder during the water tank test is indicated by dye rising to the surface of the water.

_____b. During the water tank leakage check, the cylinder is submerged in the dye tank for a period of 30 minutes.

_____c. It requires 24 hours to perform a valid weight loss check of the cylinder contents.

_____d. If, during the water tank leakage check, bubbles are seen rising to the surface of the water, the point of leakage must be located and the leak repaired and the cylinder recharged.

Answers to Frame 18: F a. F b. T c. T d.

Frame 19

After the cylinder has been charged, leak tested and reweighed, it must be stenciled with specific information to identify the cylinder, its contents and the date that it was charged. This information is stenciled on the cylinder using black stencil ink or black lacquer. One-fourth inch letters are used for the one-man cylinder and one-half inch letters for the multiplace cylinder. Stencils will be cut to include the information listed below. Look this information over closely so that you will know what is to be put on the cylinder. Always check this in the TO.

ONE-MAN CYL

CYL AND VALVE ASSY

TYPE FLU 2/P

WT EMPTY 1.55 LBS

WT CO_2 0.50 LBS

TOTAL WT 2.05 LBS

DATE RECHARGED 1 SEP 70

2100 PSI 147.63KG/CM_2

MULTIPLACE CYLINDER

CYLINDER AND VALVE ASSY

PART NO. ________________

WT EMPTY ________ LBS (includes complete valve assy and atchs)

WT CO_2 ________ LBS (enter nominal charge)

WT N_2 and CO_2 ________ LBS (enter actual weight)

WT TOTAL ________ LBS

DATE CHARGED _____________

FLEXIBLE SYPHON TUBE

U.S. PROPERTY

Complete the following statements by writing in the words from the frame above.

a. The multiplace cylinder is stenciled using _________ inch letters and ___________ ________________ ink or black ________________.

b. The one-man cylinder is stenciled using ____________ inch letters and ______________ ink or black _________________.

c. The information stenciled on the cylinder should identify the cylinder, its ____________ and the _____________ it was charged.

Answers to Frame 19: a. 1/2, black, stencil, lacquer
b. 1/4, black, lacquer c. weight, date

SERVICE TEST
PROGRAMMED TEXT
C3ABR42331-PT-405

Technical Training

Aircraft Environmental Systems Mechanic

INSPECTION AND MAINTENANCE OF LIFE RAFT CYLINDERS

16 May 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use Only.
Do Not Use on the Job.

OBJECTIVES

Using tools, applicable TOs, and workbook, inspect the valve head assemblies and cylinders. Locate a minimum of four discrepancies.

INSTRUCTIONS

This programmed text is presented in small steps called "Frames." The material contained herein will support lesson objectives given in lecture form by the instructor or objectives covered during lab work. At the end of some of the frames you may be asked to complete the statements that are TRUE. Read the information in the frames carefully then select the statements that are TRUE. If you are correct proceed to the next frame. The answers will be given on the following page. If you are wrong or in doubt, restudy the information until you correctly identify the TRUE statements.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Frame 1

You must inspect all inflation assemblies returned for recharging. Check first to see that there is no rust on the cylinder, that there are no dents, and that the paint covering is in good condition. Also, check for broken or raveling wire windings. Tag any cylinders failing the above inspections as repairable.

Select the statements that are TRUE.

_____1. You receive a cylinder for recharging. The first thing you do is to start recharging the cylinder.

_____2. You should inspect all cylinders before recharging them.

_____3. Any cylinder failing the initial inspection should be tagged repairable.

Answers to Frame 1: F 1. T 2. T 3.

Frame 2

Make certain that the cylinder is completely discharged BEFORE attempting disassembly. To discharge a cylinder, secure it in a chain vice, or other clamping device and discharge its contents into an open or ventilated area. Disassembly of the control valve, cleaning, inspection repair or replacement of parts, and reassembly are very much like work done on similar equipment. Be sure to follow procedures given in TO 14S-1-102 when you rework a control valve.

NO RESPONSE NECESSARY

Frame 3

When removing the control valve, you should examine the poppet valve for scratches, dents, burrs, or particles lodged under the seat. Defective poppet assemblies must be replaced.

NO RESPONSE NECESSARY

While the control valve is removed, inspect the interior of the cylinder to make certain that the phosphate coating is still intact and that no corrosion has started. If you have any doubt about the interior, tag the cylinder for overhaul. If there are no defects, coat the cylinder threads with a light coating of thread compound MIL-C-5542 or teflon tape or its equivalent. Install a new gasket and screw the control valve onto the cylinder. Use a chain vise or other suitable clamp to hold the cylinder, being careful not to cause damage to the cylinder. Torque the control valve to the values specified in the appropriate technical order. Also, recheck to make sure that the torque on the safety outlet plug is as specified in the technical order. If any one of the inflation assemblies does not pass the inspection requirements mentioned, it must be overhauled.

NO RESPONSE NECESSARY

Frame 5

An inflation cylinder or assembly needing overhaul requires further inspection. Remove the control valve if it has not already been removed. Remember to bleed off any pressure that may be in the cylinder before removal of the control valve. Then, inspect the cylinder carefully, both internally and externally, for damage or corrosion. Make sure that the threads on the control valve and the cylinder are in good condition.

NO RESPONSE NECESSARY

Frame 6

Condemn welded-type cylinders that have extensive scratches, dents, or other that weaken them to the extent that they are unsafe for use under high pressure. Condemned cylinders of any type should further be made unusable by damaging the threads. These cylinders should then be tagged as condemned. The only procedure that can really be called repair to a cylinder is refacing the seating surface for the control valve if it has become rough or pitted.

Select the statements that are TRUE.

_____1. Welded-type cylinders that have alot of dents and scratches should be repaird.

_____2. To further condemn a cylinder, you should damage the threads.

_____3. Condemned cylinders should be tagged as condemned.

Answers to Frame 6: _F_ 1. _T_ 2. _T_ 3.

Frame 7

For complete inspection and overhaul requirements, you should always follow the instructions as outlined in the applicable technical order.

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-SG-405
2 August 1984

LIFE RAFT INFLATION EQUIPMENT

OBJECTIVE

State general principles relating to the operation of life raft inflation equipment. A minimum of four out of five must be correct.

INSTRUCTIONS

The information contained in this study guide was designed to supplement the lesson given by the instructor. This material can be used to study for the measurement test or to complete the progress check for the particular objective.

INTRODUCTION

Our career field is not responsible for the maintenance of life rafts, but we do have the responsibility of servicing, inspecting, overhauling, and recharging all life raft inflation equipment. For this reason, it is necessary for you to know the means by which these life rafts are inflated.

CYLINDERS

High pressure carbon dioxide (CO_2) cylinders are used for the inflation of all life rafts. The cylinders are built to carry a maximum charge of 2100 psi. Because of the high pressure to which they are subjected, all life raft cylinders except those having an outside diameter of less than two inches and a length of less than two feet, must undergo a hydrostatic test once every five (5) years. This test is used to find out whether or not corrosion, metal fatigue, rough handling, or other causes may have weakened the cylinders to a point where they are no longer safe for further use.

Supersedes ST C3ABR42331-SG-405, 23 March 1984.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Designed for ATC Course Use. Do Not Use on the Job.

ONE-MAN LIFE RAFT CYLINDERS

The first type of life-raft cylinder we will discuss is the one-man life raft cylinder. There are two types approved for use. They are shown below. Both assemblies use the same valve head, but type FLU 2/P uses a heavy forged steel cylinder. While type FLU 2-A/P uses a light weight aluminum welded cylinder. They both contain the same amount of CO_2 by weight even though they are different in length. These cylinders do not require a hydrostatic test.

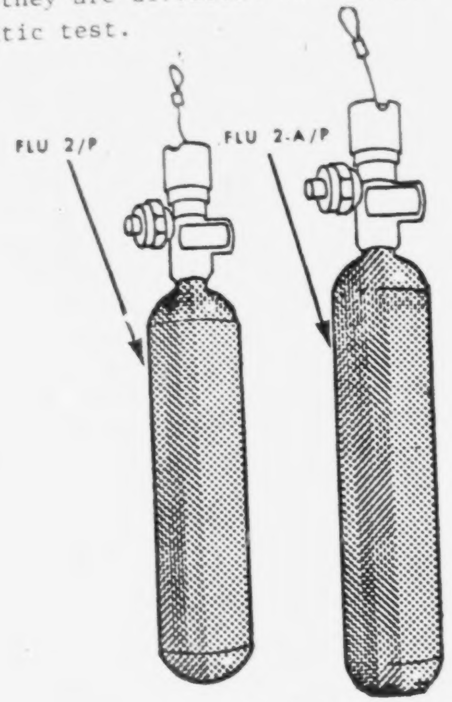
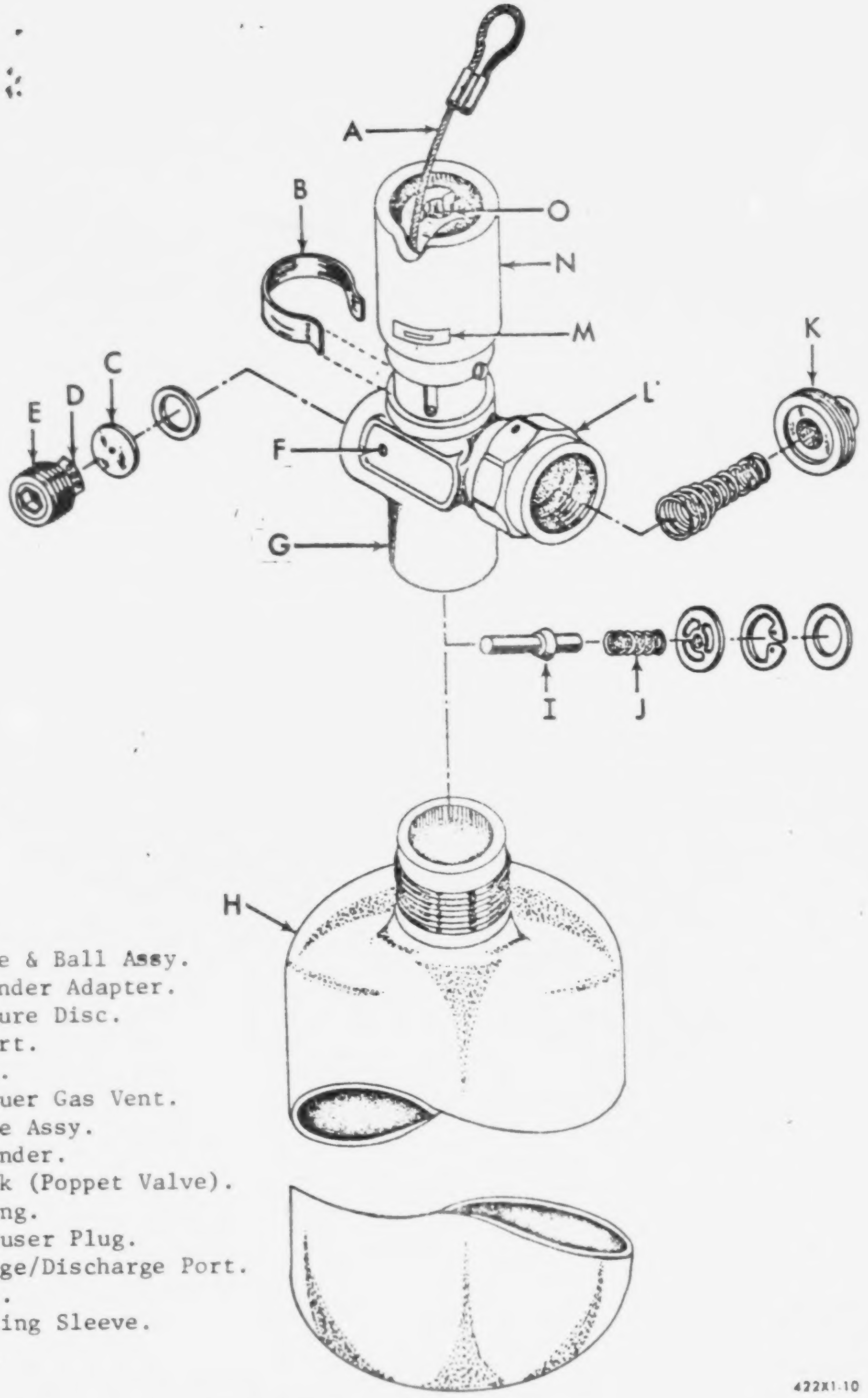


Figure 1. One-Man Cylinders.

ONE-MAN CYLINDER OPERATION

Refer to figure 2 while we discuss the operation of the valve that is used on the one-man life raft cylinders. The valve assembly is made for rapid flow and always has a safety rupture disc. A round ball (not shown) on the inner end of the cable assembly (A) is engaged in the slot in the rotating cam (O). The ball is engaged in the slot by raising a small locking spring in the slot (M), then sliding the locking sleeve (N) down to expose the cam, and then positioning the cable and ball assembly. When the cable (A) is pulled, the cam rotates and pushes down on the check (I) which is normally held against its seat by the spring (J) and CO_2 pressure within the cylinder. The CO_2 now floods out the charge/discharge port (L) into the life raft. If the pressure in the cylinder should become dangerously high, it will break the rupture disc (C) and the CO_2 will go out through the holes in the insert (D) and out through the vent holes (F) in the valve body to the atmosphere. The diffuser plug (K) is installed at all times except when the assembly is being recharged or is actually attached to the life raft. The purpose of the diffuser plug is to prevent a pinwheel action of the cylinder resulting from the jet effect of the escaping gas if the cylinder is discharged.


A
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422X1-10

A - Cable & Ball Assy.
B - Cylinder Adapter.
C - Rupture Disc.
D - Insert.
E - Plug.
F - Ruptuer Gas Vent.
G - Valve Assy.
H - Cylinder.
I - Check (Poppet Valve).
J - Spring.
K - Diffuser Plug.
L - Charge/Discharge Port.
M - Slot.
N - Locking Sleeve.
O - Cam.

Figure 2. One-Man Assembly.

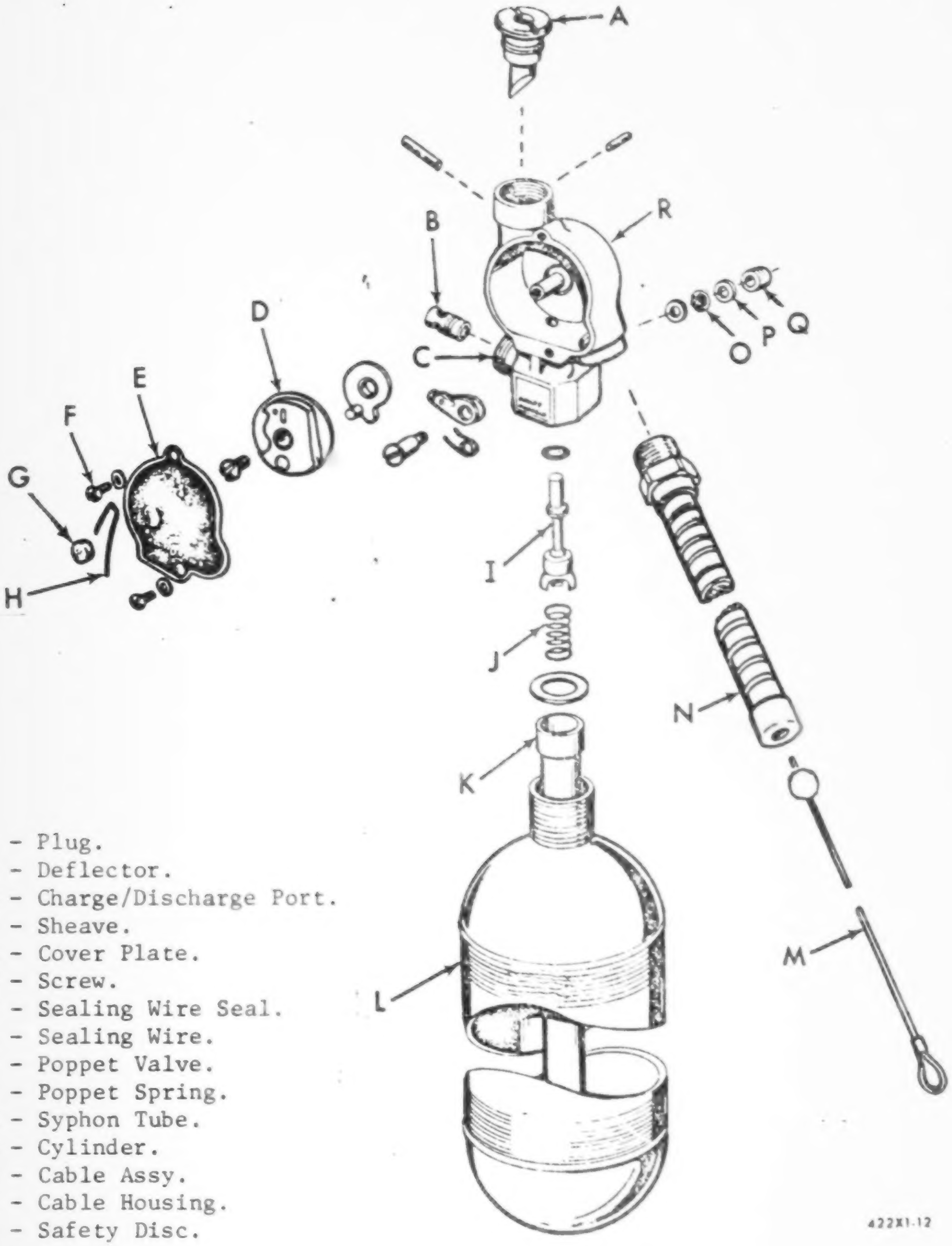
MULTI-PLACE CYLINDER

The next cylinder we will discuss is the multi-place cylinder. Multi-place life raft cylinders are used with life rafts carrying two or more men. All multi-place life raft cylinders are wound with wire to give them added strength and to make them shatter resistant when they are struck by gunfire.

OPERATION OF MULTI-PLACE CYLINDERS

Refer to figure 3 while we discuss the operation of the valve that is used on the multi-place life raft cylinders. When the pull cable (M) is pulled to discharge the cylinder, it rotates a sheave (D). A hole in the sheave fits over a pin that is located on a cam that is below the sheave. The rotation of the cam depresses a lever arm which contacts the end of the poppet valve (I) and pushes it down. This unseats the poppet valve. With the poppet valve unseated, the gas rushes out through the charge/discharge port (C) and inflates the life raft. When the cylinder is charged, the spring (J) and gas pressure hold the poppet valve (I) closed. Notice that this cylinder has a syphon tube (K) to insure that the liquid CO_2 is discharged as well as the gas.

Depending on the angle that the cylinder is to be installed, the pull cable can be rigged in either the DOWN PULL position, as shown in figure 4, or in the UP PULL position by reversing the positions of the cable housing (N) and the plug assembly (A) as shown in figure 3. The ball on the end of the cable must be engaged in the proper recess on the sheave marked DOWN PULL or UP PULL. As long as the control cable has not been pulled to discharge the cylinder, a green dot on the sheave shows through the window in the sheave cover plate, as indicated in figure 4. When the cylinder is charged and rigged for use, a lead seal is placed on the safety wire which passes through two holes in the sheave cover plate and is twisted around a cover hold-down screw (figure 4). Once the cable is pulled and the sheave rotated to discharge the cylinder, it cannot be reset without breaking the seal and removing the cover plate. Items O, P, and Q in figure 3 are the rupture disc, insert, and plug which allows the gas to escape if the cylinder pressure should become dangerously high.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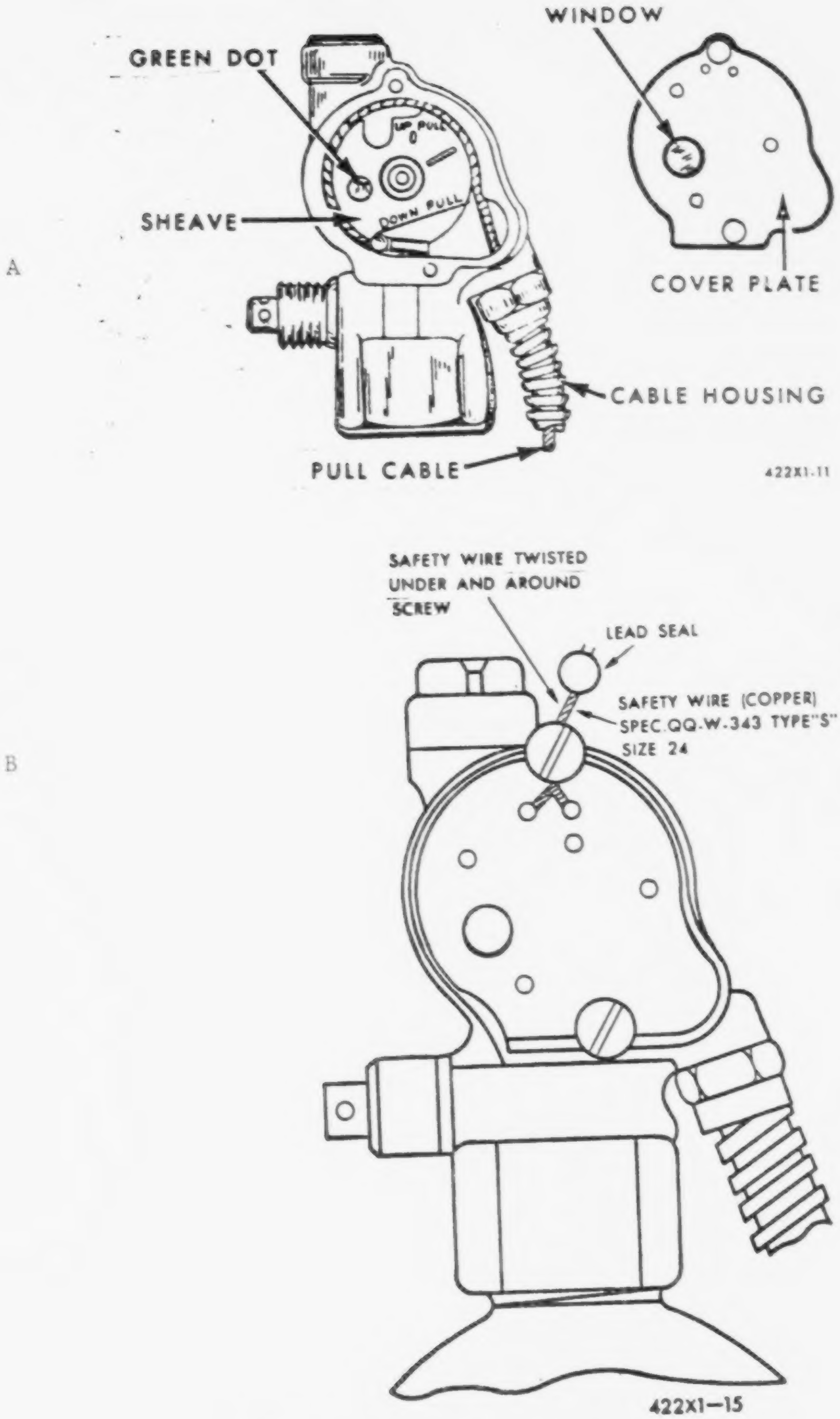
422X1-12

A - Plug.
B - Deflector.
C - Charge/Discharge Port.
D - Sheave.
E - Cover Plate.
F - Screw.
G - Sealing Wire Seal.
H - Sealing Wire.
I - Poppet Valve.
J - Poppet Spring.
K - Syphon Tube.
L - Cylinder.
M - Cable Assy.
N - Cable Housing.
O - Safety Disc.
P - Insert.
Q - Plug.
R - Body.

Figure 3. Multi-place Assembly.



A
GREEN DOT
WINDOW
UP PULL
DOWN PULL
SHEAVE
COVER PLATE
CABLE HOUSING
PULL CABLE
422X1-11
B
SAFETY WIRE TWISTED UNDER AND AROUND SCREW
LEAD SEAL
SAFETY WIRE (COPPER) SPEC.QQ-W-343 TYPE"S" SIZE 24
422X1—15

Figure 4. Multiplace Control Head.

When servicing multi-place life raft cylinders, a charge of dry nitrogen (N2) is added to help expel the CO_2 at low temperatures. We will go into servicing life raft cylinders in more detail in WB-405.

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-SG-405
2 August 1984

LIFE RAFT INFLATION EQUIPMENT

OBJECTIVE

State general principles relating to the operation of life raft inflation equipment. A minimum of four out of five must be correct.

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Supersedes ST C3ABR42331-SG-405, 23 March 1984.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 300; DAV - 1

Designed for ATC Course Use. Do Not Use on the Job.

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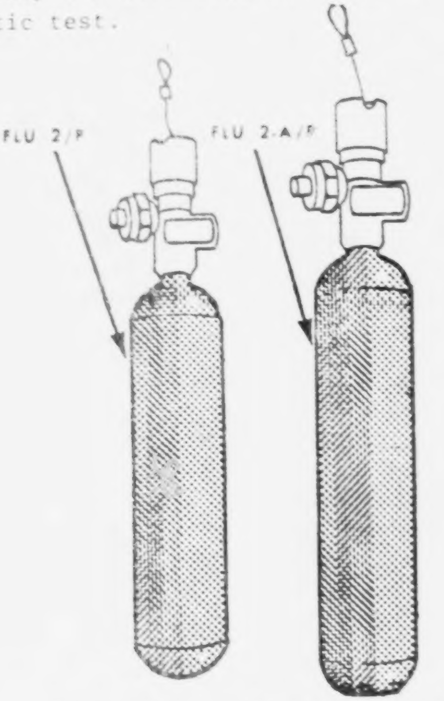
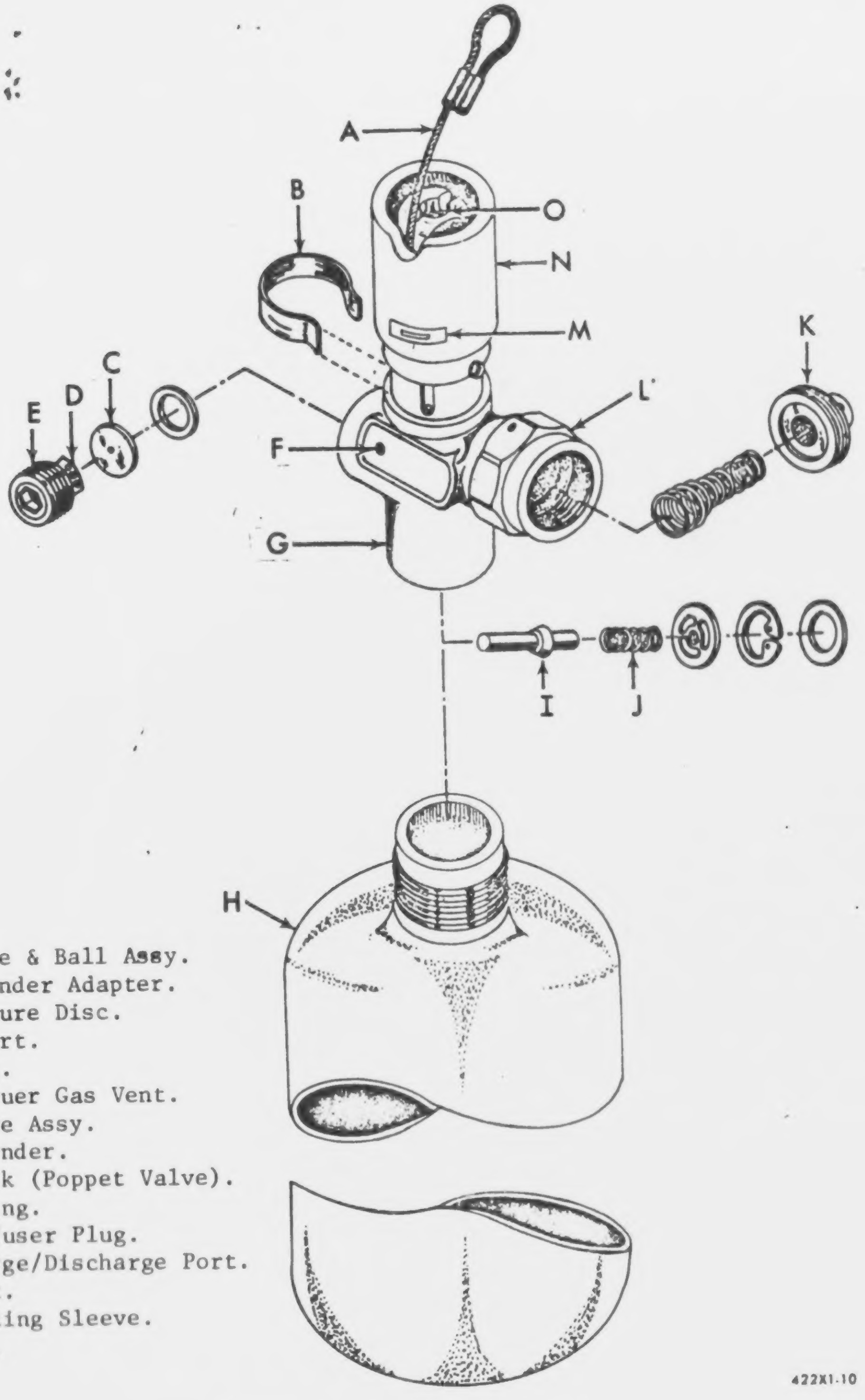


Figure 1. One-Man Cylinders.

ONE-MAN CYLINDER OPERATION

Refer to figure 2 while we discuss the operation of the valve that is used on the one-man life raft cylinders. The valve assembly is made for rapid flow and always has a safety rupture disc. A round ball (not shown) on the inner end of the cable assembly (A) is engaged in the slot in the rotating cam (O). The ball is engaged in the slot by raising a small locking spring in the slot (M), then sliding the locking sleeve (N) down to expose the cam, and then positioning the cable and ball assembly. When the cable (A) is pulled, the cam rotates and pushes down on the check (I) which is normally held against its seat by the spring (J) and CO_2 pressure within the cylinder. The CO_2 now floods out the charge/discharge port (L) into the life raft. If the pressure in the cylinder should become dangerously high, it will break the rupture disc (C) and the CO_2 will go out through the holes in the insert (D) and out through the vent holes (F) in the valve body to the atmosphere. The diffuser plug (K) is installed at all times except when the assembly is being recharged or is actually attached to the life raft. The purpose of the diffuser plug is to prevent a pinwheel action of the cylinder resulting from the jet effect of the escaping gas if the cylinder is discharged.


A
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422X1-10

A - Cable & Ball Assy.
B - Cylinder Adapter.
C - Rupture Disc.
D - Insert.
E - Plug.
F - Ruptuer Gas Vent.
G - Valve Assy.
H - Cylinder.
I - Check (Poppet Valve).
J - Spring.
K - Diffuser Plug.
L - Charge/Discharge Port.
M - Slot.
N - Locking Sleeve.
O - Cam.

Figure 2. One-Man Assembly.

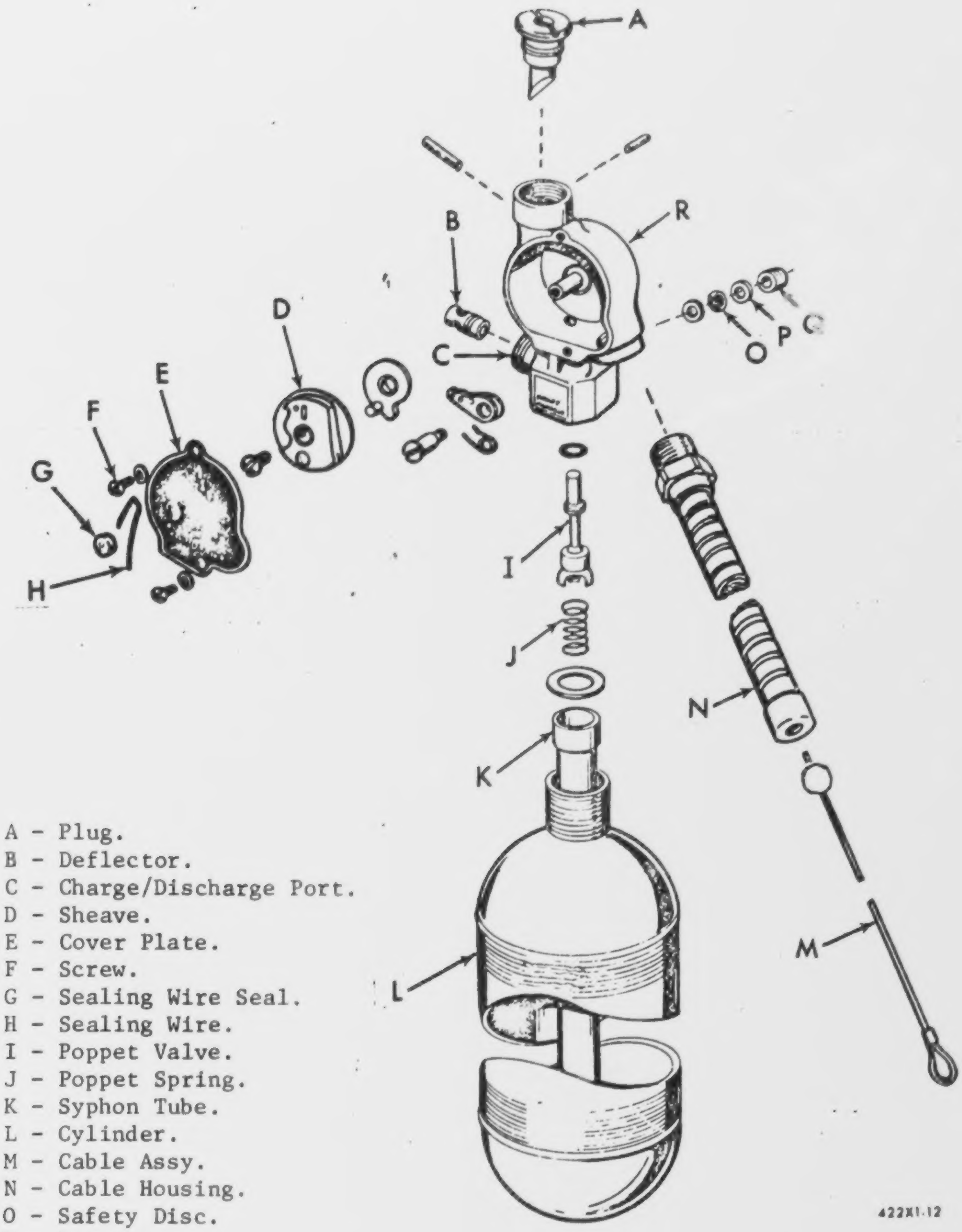
MULTI-PLACE CYLINDER

The next cylinder we will discuss is the multi-place cylinder. Multi-place life raft cylinders are used with life rafts carrying two or more men. All multi-place life raft cylinders are wound with wire to give them added strength and to make them shatter resistant when they are struck by gunfire.

OPERATION OF MULTI-PLACE CYLINDERS

Refer to figure 3 while we discuss the operation of the valve that is used on the multi-place life raft cylinders. When the pull cable (M) is pulled to discharge the cylinder, it rotates a sheave (D). A hole in the sheave fits over a pin that is located on a cam that is below the sheave. The rotation of the cam depresses a lever arm which contacts the end of the poppet valve (I) and pushes it down. This unseats the poppet valve. With the poppet valve unseated, the gas rushes out through the charge/discharge port (C) and inflates the life raft. When the cylinder is charged, the spring (J) and gas pressure hold the poppet valve (I) closed. Notice that this cylinder has a syphon tube (K) to insure that the liquid CO_2 is discharged as well as the gas.

Depending on the angle that the cylinder is to be installed, the pull cable can be rigged in either the DOWN PULL position, as shown in figure 4, or in the UP PULL position by reversing the positions of the cable housing (N) and the plug assembly (A) as shown in figure 3. The ball on the end of the cable must be engaged in the proper recess on the sheave marked DOWN PULL or UP PULL. As long as the control cable has not been pulled to discharge the cylinder, a green dot on the sheave shows through the window in the sheave cover plate, as indicated in figure 4. When the cylinder is charged and rigged for use, a lead seal is placed on the safety wire which passes through two holes in the sheave cover plate and is twisted around a cover hold-down screw (figure 4). Once the cable is pulled and the sheave rotated to discharge the cylinder, it cannot be reset without breaking the seal and removing the cover plate. Items O, P, and Q in figure 3 are the rupture disc, insert, and plug which allows the gas to escape if the cylinder pressure should become dangerously high.


A
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422X1.12

A - Plug.
B - Deflector.
C - Charge/Discharge Port.
D - Sheave.
E - Cover Plate.
F - Screw.
G - Sealing Wire Seal.
H - Sealing Wire.
I - Poppet Valve.
J - Poppet Spring.
K - Syphon Tube.
L - Cylinder.
M - Cable Assy.
N - Cable Housing.
O - Safety Disc.
P - Insert.
Q - Plug.
R - Body.

Figure 3. Multi-place Assembly.

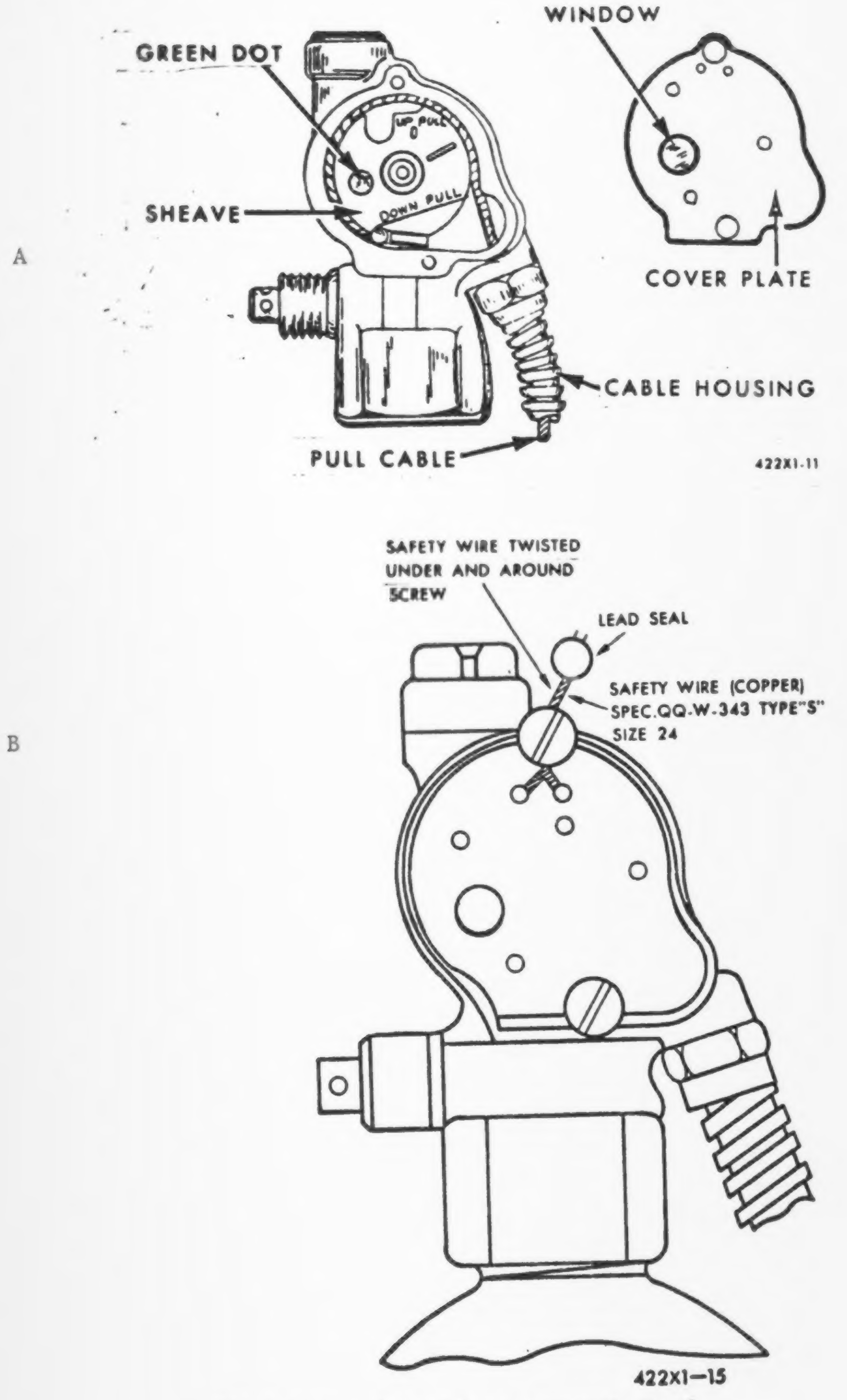

A
GREEN DOT
WINDOW
UP PULL
DOWN PULL
SHEAVE
COVER PLATE
CABLE HOUSING
PULL CABLE
422X1-11
B
SAFETY WIRE TWISTED UNDER AND AROUND SCREW
LEAD SEAL
SAFETY WIRE (COPPER) SPEC.QQ.W-343 TYPE"S" SIZE 24
422X1—15

Figure 4. Multiplace Control Head.

When servicing multi-place life raft cylinders, a charge of dry nitrogen (N2) is added to help expel the CO_2 at low temperatures. We will go into servicing life raft cylinders in more detail in WB-405.

SERVICE TEST
WORKBOOK
C3ABR42331-WB-405

Technical Training

Aircraft Environmental Systems Mechanic

INSPECTION, OVERHAUL, AND RECHARGING LIFE RAFT CYLINDERS

9 November 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE
DO NOT USE ON THE JOB

ISNPECTION, OVERHAUL, AND RECHARGING LIFE RAFT CYLINDERS

OBJECTIVES

1. Using tools, applicable TOs, and workbook, inspect the valve head assemblies and cylinders. A maximum of two instructor assists are allowed. Apply safety precautions without error.

2. Using the life raft inflation cylinder recharging equipment, scales, tools, applicable TOs, workbook, and working in a group of not more than two students, service a life raft cylinder IAW TO tolerances and discharge cylinder safely. A maximum of three instructor assists are allowed. Apply safety precautions without error.

EQUIPMENT

Recharging unit, carbon dioxide
Scale, dial and beam indicating
Life raft inflation cylinder
Handtools

PROCEDURE

Obtain a one-man and a multiplace life raft cylinder from your instructor. Inspect the life raft cylinders using TO 14S-1-102 and workbook. Read Section 2-2, pages 2-17 thru 2-23, and para 2-50 thru 2-51 in TO then use workbook and inspect the cylinders.

Section I. INSPECTION AND OVERHAUL OF ONE-MAN LIFE RAFT INFLATION CYLINDER ASSEMBLY

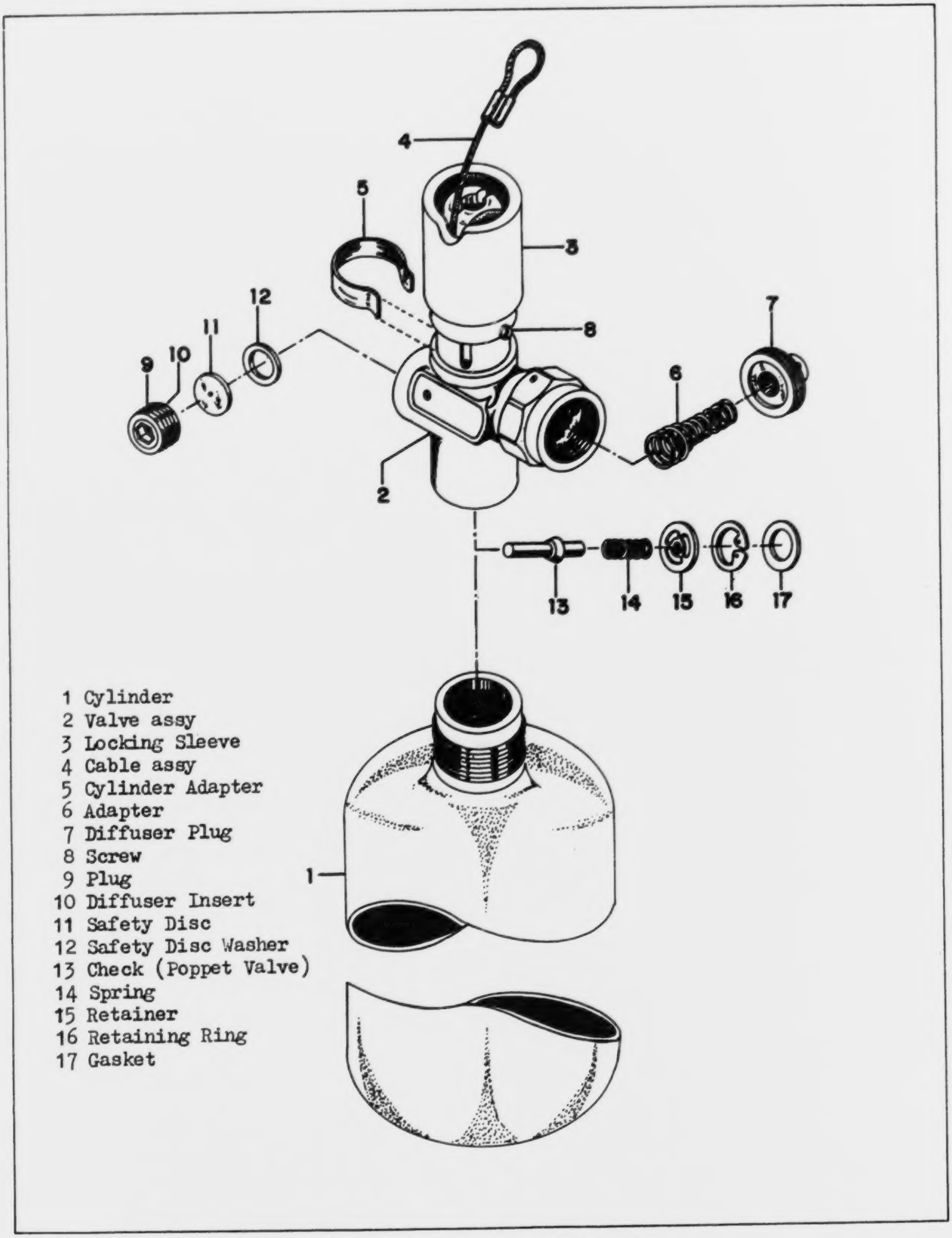
1. Using the one-man life raft cylinder provided (type FLU-2A/P or FLU-2/P), visually inspect the cylinder for the following conditions:

   a. Rust on the cylinder (none allowed).

   b. Excessive dents in the cylinder (none allowed).

   c. Condition of the paint.

OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 200; DAV - 1



1 Cylinder
2 Valve assy
3 Locking Sleeve
4 Cable assy
5 Cylinder Adapter
6 Adapter
7 Diffuser Plug
8 Screw
9 Plug
10 Diffuser Insert
11 Safety Disc
12 Safety Disc Washer
13 Check (Poppet Valve)
14 Spring
15 Retainer
16 Retaining Ring
17 Gasket

Figure 1 **Inflation Assembly (Bendix)**

List any defects discovered:

2. Note figure 2. Remove cylinder adapter (5, figure 1) insert the end of a small paper clip in the slot in the side of the locking sleeve (3, figure 1) and push the spring slip lock to release the locking sleeve.

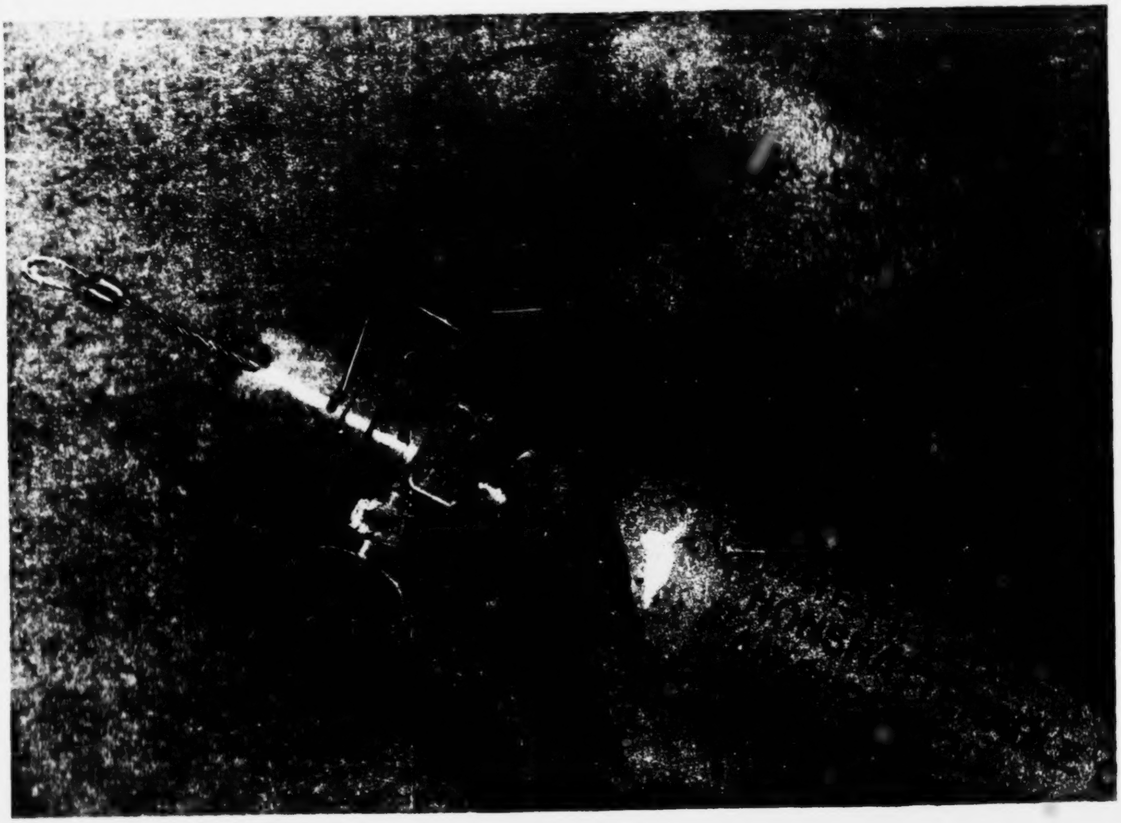


Figure 2. Releasing Spring on Locking Sleeve.

3. Lower the locking sleeve and remove the cable and ball assembly (4, figure 1).

4. Inspect the locking sleeve for nicks and for free up and down movement.

5. Inspect the cable assembly for fraying and a loosened ball on the end of the cable. List any defects discovered:

6. Note figure 3. Insert the metal rod provided into the cable ball hole of the cam and operate the cam to open the valve.

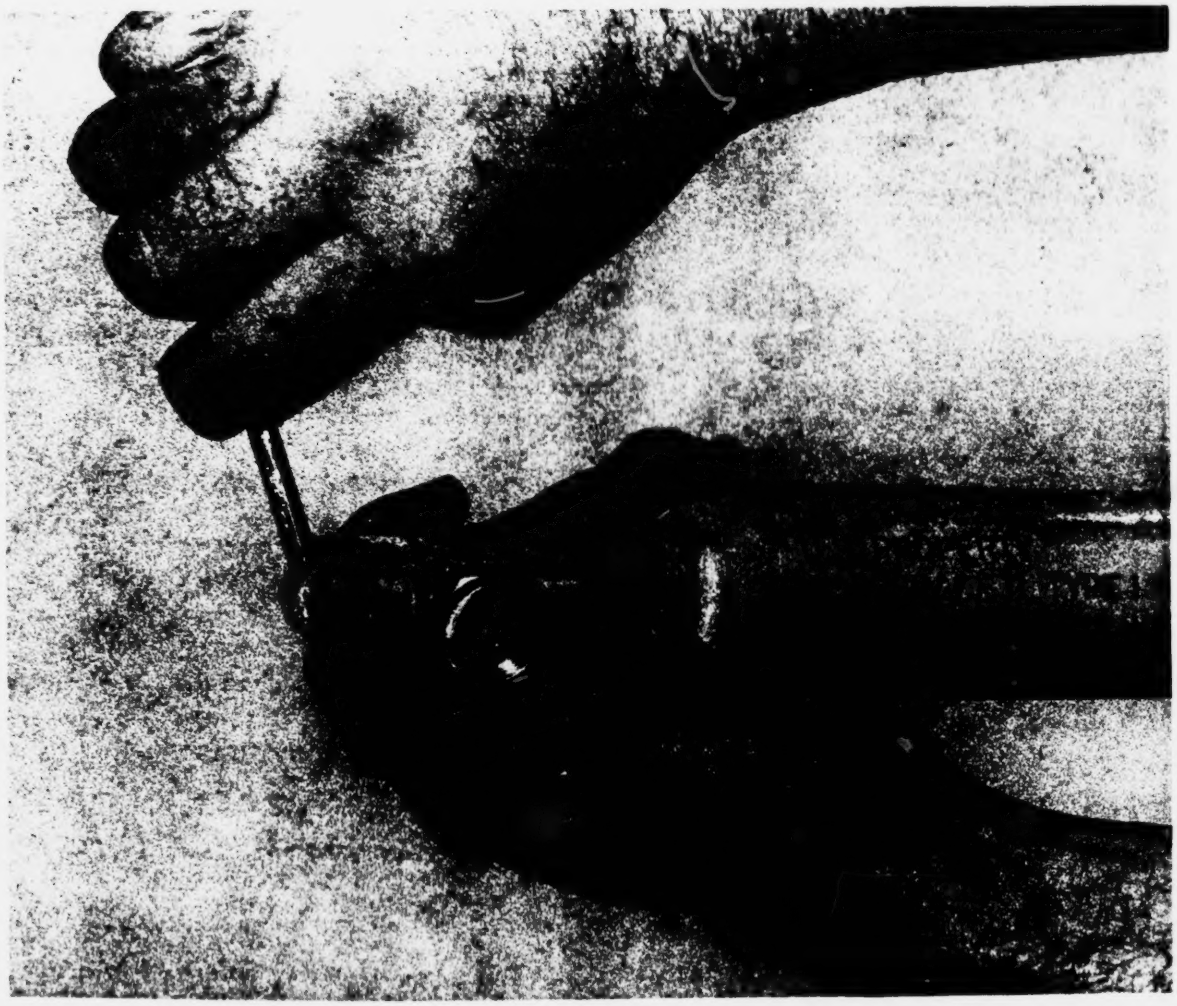


Figure 3. Operating Cam with Metal Rod.

Note: A charged cylinder can be discharged in this manner, or if the cylinder is overcharged during the charging operation, the metal rod is used to "bleed down" the cylinder to the proper weight in the event of an overcharge. The cam is also placed in this open position for charging the cylinder with CO_2. Be sure diffuser plug is installed after cylinder is properly charged with CO_2.

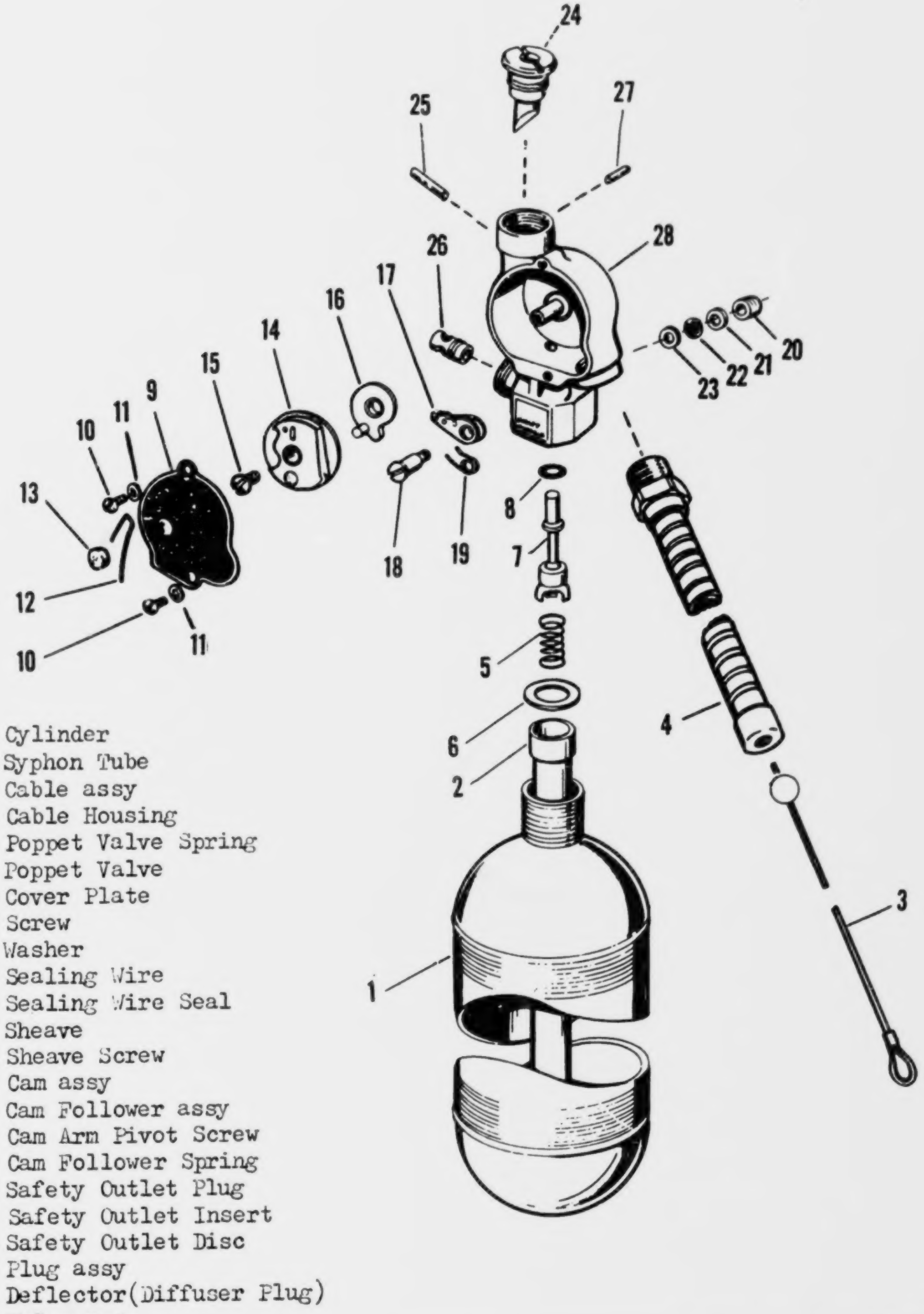
7. Using the metal rod, operate the cam to the reset position.

8. Replace the cable and ball assembly and raise the locking sleeve to the locked position.

Section II

INSPECTION AND OVERHAUL OF MULTIPLACE LIFE RAFT INFLATION CYLINDER ASSEMBLY

Refer to Figure 4 for an illustrated breakdown of the cylinder assembly.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1 Cylinder
2 Syphon Tube
3 Cable assy
4 Cable Housing
5 Poppet Valve Spring
7 Poppet Valve
9 Cover Plate
10 Screw
11 Washer
12 Sealing Wire
13 Sealing Wire Seal
14 Sheave
15 Sheave Screw
16 Cam assy
17 Cam Follower assy
18 Cam Arm Pivot Screw
19 Cam Follower Spring
20 Safety Outlet Plug
21 Safety Outlet Insert
22 Safety Outlet Disc
24 Plug assy
26 Deflector(Diffuser Plug)
28 Valve Body

Figure 4. Cylinder and Valve Assembly, Part Number 55C3689.

1. Using the cylinder assembly provided, remove the cover plate (9) from the valve assembly by removing the two screws (10) and washers (11).

2. Disengage the cable assembly (3) from the sheave (14) and remove the sheave by removing the screw (15) which holds it in place.

3. Perform the following visual inspections of parts removed:

   a. Surfaces of valve parts for scratches, scoring, or dirt.

   b. Cover plate for loose rivets or damaged window.

   c. Sheave for burrs, cracks, or damage that would cause a malfunction.

   d. Cable assembly for fraying and that the ball on the end of the cable is secure.

List any defects discovered:

____

____

____

4. Install the sheave, engaging the pin on the cam (16) into the hole in the sheave.

5. Install the sheave retaining screw.

6. Rotate the sheave to the discharged position (all the way to the right.

Note: Final assembly will be completed after recharging of the cylinder.

Section III. CYLINDER RECHARGING

Warning: Any charged or partially charged gas cylinder of any size is potentially dangerous and must always be handled with caution. Handle all compressed gas cylinders carefully, never drop them or permit them to strike each other violently. Discharge valves of cylinders must not be bumped or knocked. Cylinders must be secured in a chain vise or other approved clamping device when being discharged. Protective gloves and a face mask or goggles must be worn throughout the cylinder charging process.

During your cylinder recharging procedure, refer to the diagram (figure 5) of the recharging set-up provided. For training purposes, all valves on the recharging set-up which are identified by letters on the diagram have been color coded. The instructor will inform you of the type of life raft that the cylinder you are recharging is used on.

At this time obtain TO 14S-1-102 from instructor.

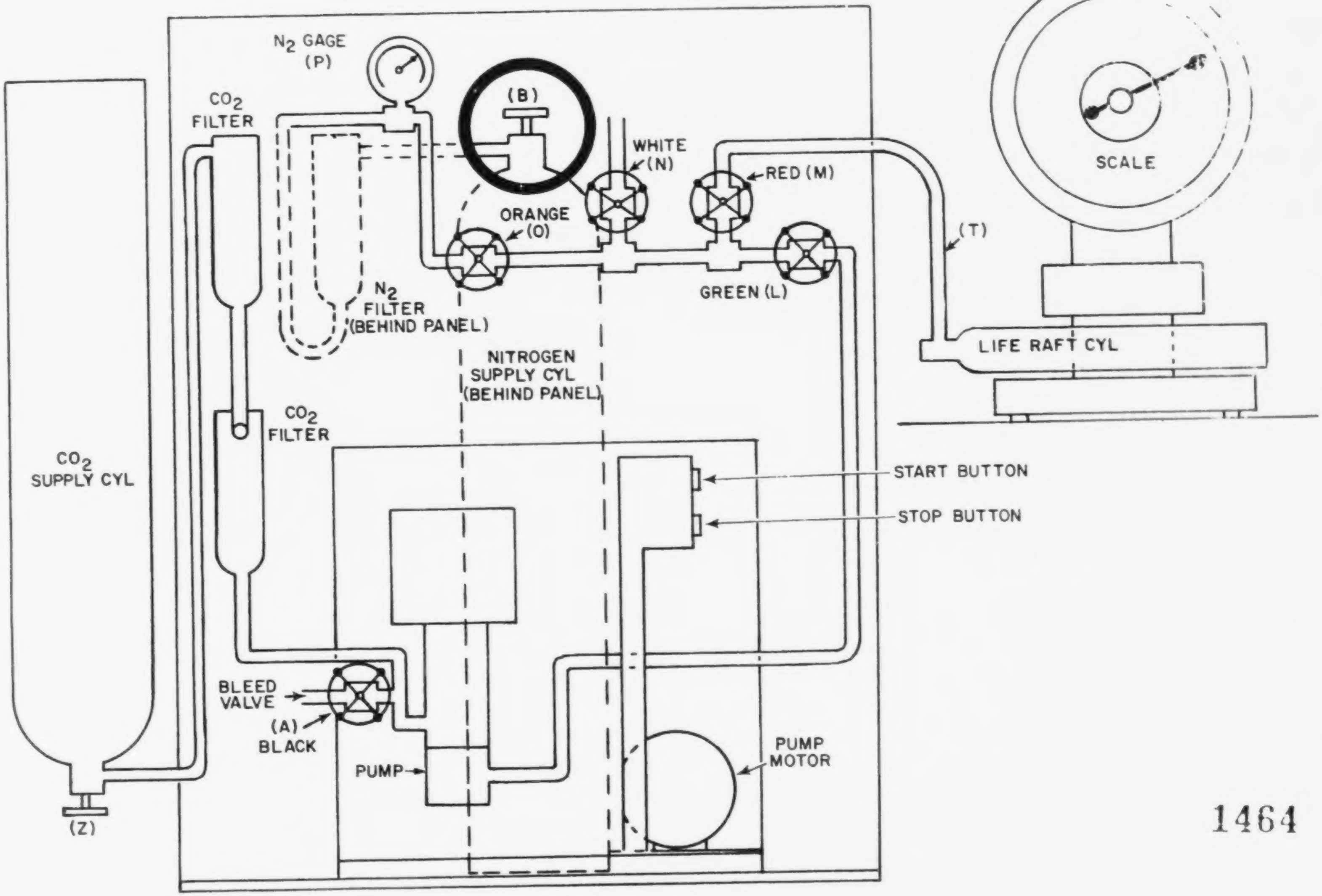
N2 GAGE
(P)
(B)
CO2 FILTER
WHITE
(N)
RED (M)
SCALE
ORANGE
(O)
(T)
N2 FILTER (BEHIND PANEL)
GREEN (L)
LIFE RAFT CYL
NITROGEN SUPPLY CYL (BEHIND PANEL)
CO2 FILTER
CO2 SUPPLY CYL
START BUTTON
STOP BUTTON
BLEED VALVE
(A)
BLACK
PUMP
PUMP MOTOR
(Z)

Figure 5.

1. For what types of life rafts is this cylinder used? ___________

2. Note the empty weight of the cylinder assembly stenciled on the cylinder. The empty cylinder weight is ___________ lbs.

3. Place the cylinder in the holding adapter on the scale.

4. Place cover plate, screws and cable assembly in holding adapter with cylinder on the scale. At this time you will put the weights that are provided on the opposite side of the bottle on the scale until the weights and the bottle are balanced. Now add the total amount of weights added to the scale along with the reading on the scale. This gives you the total empty weight of the cylinder. The empty cylinder weight is _______ lbs. See your instructor.

5. Using teflon (anti-seize) tape, install charging adapter to cylinder. Obtain adapter from your instructor.

6. Make sure all valves on the recharging set-up are CLOSED.

7. Slowly open the valve (B) on the nitrogen supply cylinder by reaching through the opening in the top of the panel. Note that nitrogen supply pressure shows on the pressure gage (P). If it does not, consult your instructor. Does a reading show on the pressure gage? _____________

8. Open the ORANGE valve (O) in the nitrogen supply line.

9. Open the RED valve (M) in the cylinder charging line momentarily to purge air out of the charging hose (T). Insure the charging hose is pointed away from personnel.

10. Close the RED valve (M) and immediately connect the charging hose (T) to the cylinder to be charged. Use 2 wrenches to tighten the connection.

11. Insure that the charging hose is not twisted once charging hose is installed. Readjust scale so that the pointer is located on the zero mark or the one pound mark. This is done by moving the small weight located on the bottom left hand corner of the scale away from you until your mark is reached.

12. Refer to table 2-2 in TO 14S-1-102 and note the weight of N_2 to be added to the cylinder you are recharging. The specified weight of N_2 is __________ lb.

13. While watching the pointer on the scale, slightly open the RED valve (M) and when the pointer has moved to the specified weight on the scale dial, CLOSE the valve.

If a cylinder is overcharged with N_2 or CO_2, it must be bled down to the proper weight by placing a screwdriver in the slot in the sheave and carefully rotating the sheave clockwise. Note figure 6.

14. Close the valve (B) on the N_2 supply cylinder.

15. Open the WHITE bleed valve (N) to bleed nitrogen pressure from the line, then CLOSE the valve.

16. Close the ORANGE valve (O) in the nitrogen supply line.

17. Again refer to table 2-2 in TO 14S-1-102 and determine the weight of CO_2 for the cylinder you are recharging. The specified weight of CO_2 is ________ lbs.

18. Reset the scale to read exactly zero or 1 pound by repositioning the weights on the top and left side balance bars.

19. Slowly open the valve (Z) on the CO_2 supply cylinder.

20. Crack open the BLACK bleed valve (A) at the pump inlet until liquid CO_2 is flowing freely from the supply cylinder, then CLOSE the valve. The dehydrator filters must first fill with liquid CO_2.

21. Open the GREEN valve (L) in the pump outlet line.

22. Crack open the WHITE bleed valve (N) which will allow CO_2 gas to be purged from the pump. Close this valve as soon as liquid CO_2 appears or gas no longer flows.

Note: Read the following caution and steps 23 through 25 carefully before beginning.

23. Open the RED valve (M) then start recharging unit by pressing the START button on the pump.

Caution: You must stop the pump before closing the RED or GREEN valves in the outlet charging line from the pump. Failure to do so may result in blowing the safety rupture disc at the pump outlet.

24. Carefully watch the scale and when it reads the weight of CO_2 to be added, quickly press the STOP button to stop the recharging unit.

25. As soon as the pump stops, close the RED valve (M).

26. Close the valve (Z) on the CO_2 supply cylinder, and close cylinder valve with screwdriver after cylinder valve is closed, open RED valve (M).

27. Open the WHITE bleed valve and GREEN valve to bleed CO_2 pressure from the line.

28. Using two wrenches, slowly loosen the hose adapter connection at the life raft cylinder and disconnect the hose from the adapter. Remove adapter.

29. Weigh charged cylinder for specified weight. Charged cylinder weight is __________ lbs.

Note: If a cylinder is overcharged, it must be bled down to the proper weight by placing a screwdriver in the slot in the sheave and carefully rotating the sheave clockwise to release the excess pressure.

30. Remove the cylinder from the scale.

31. Unplug the power cable from the electrical power outlet and secure the cable.

Section IV. FINAL CYLINDER ASSEMBLY - Refer to figure 4.

Caution: You must use care while installing pull cable; the cylinder is charged.

1. Note figure 6. Slide the cable assembly through the cable housing and wrap it around the sheave, engaging the ball in the recess of the sheave for the DOWN PULL position.

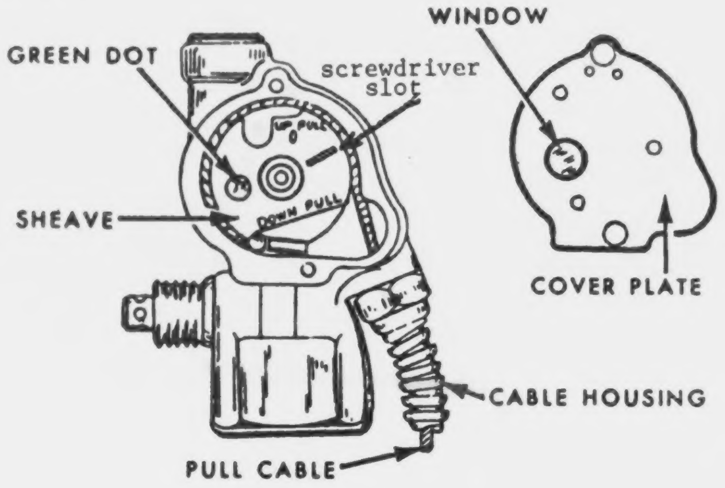

Figure 6.

Note the small hole through the top edge of the sheave for installing a piece of copper safety wire. Note figure 7. The two ends of the safety wire are passed up through the two small holes in the cover plate, wrapped around a cover plate screw, and sealed with a lead seal. This safety wire is broken when the cable is pulled to discharge the cylinder.

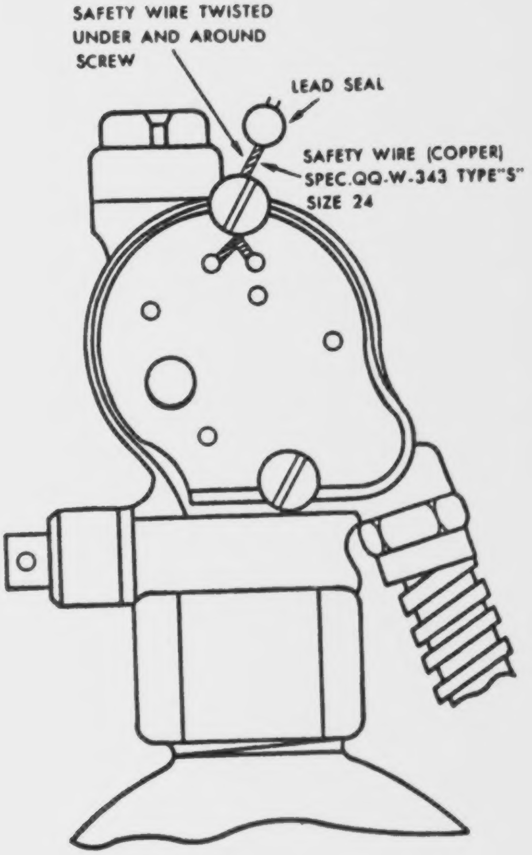
SAFETY WIRE TWISTED UNDER AND AROUND SCREW
LEAD SEAL
SAFETY WIRE (COPPER) SPEC.QQ-W-343 TYPE "S" SIZE 24

Figure 7. Multiplace Control Head.

Caution: Note the under side of the valve cover plate. Modified cover plates have a leaf spring installed inside the flange on the cover plate to ensure that the pull cable remains in place around the sheave. When installing the modified cover plate, first rotate it to the right approximately 40 degrees in order for the projecting end of the spring to clear the sheave.

2. Assemble the cover plate (9) to the valve body (28) with the washers (11) and screws (10). Make sure the green indicator dot is visible through the window in the cover plate. See your instructor for discharge method.

WORKBOOK
C3ABR42331 000-WB-406

Technical Training

Aircraft Environmental Systems Mechanic

FIRE EXTINGUISHING LABORATORY PROJECTS

28 September 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE.

DO NOT USE ON THE JOB.

RGL: N/A

Environmental Pneudraulic Branch
Chanute AFB, Illinois

C3ABR42331 000-WB-406

FIRE EXTINGUISHING LABORATORY PROJECTS

OBJECTIVES

1. Using a fire extinguishing trainer, inspection workcard, -06 code book and workbook, inspect the fire extinguishing system. Locate and record a minimum of 5 discrepancies on AFTO Forms 349. A maximum of 3 instructor assists are allowed. Apply safety precautions without error.

2. Using a fire extinguishing trainer and workbook, perform an operational check of the fire extinguishing system. A maximum of 1 instructor assist is allowed. Apply safety precautions without error.

3. Using a fire extinguisher trainer, multimeter and workbook, troubleshoot a fire extinguishing system for malfunctions. Locate and record a minimum of 4 out of 5 causes correctly. A maximum of 2 instructor assists are allowed. Apply safety precautions without error.

4. **Using container, ignition circuit tester and workbook, bench check squibs for proper resistance values. A maximum of one instructor assist is allowed. Apply safety precautions without error.**

EQUIPMENT

Fire Extinguishing Trainer
AFTO Forms 349
-06 Code Manual
Multimeter
Ignition Circuit Tester
Squibs
Container

Note: Procedures that have an asterisk (*) in front of them are considered to be the hardest tasks. Instructor assists may be given on them as stated in the objectives.

PROCEDURE

PROJECT 1

Inspection Procedures

1. Have the instructor set up the fire extinguishing film on the VCR and TV. View the film, when the film is over, tell the instructor and ask him/her any questions you may have about the fire extinguishing system.

Supersedes C3ABR42331-WB-406, 4 May 1983.
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DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

2. Using the AFTO Form 26, provided by your instructor, as a guide, inspect each item listed. Record a minimum of 5 discrepancies on AFTO Forms 349. You are allowed a maximum of 3 instructor assists for this project. Turn in your completed 349s to your instructor. Wait for his/her approval to start project 2.

Instructor's Initials ___________

Instructor Assists: 1. ___, 2. ___, 3. ___

PROJECT 2

Operational Check Procedures

Any trainer malfunction should be brought to the instructor's attention.

1. Remove all jewelry before operating this equipment

2. Inspect the fire extinguishing trainer for the following:

    a. All circuit breakers are pushed in.

    b. All fire handles are pushed in.

    c. Bottle selector switch for engine 1 and 2 in NORM (normal).

    d. All trouble switches in the out position (located on back of the trainer).

3. Connect the trainer to 28V DC. The power cord is coiled up behind the trainer. 28V DC outlets are on the wall.

4. Place the trainer power master switch "ON." This switch is located directly below the box containing the trouble switches.

5. Now visually check the following:

    a. Squib firing lights (RED) should be "OFF."

    b. Annunciator panel lights (RED) for fire bottles Number 1 and Number 2 should be "OFF."

    c. The HYD shutoff valve (hydraulic) should be "OPEN" (amber indicating light "OFF").

    d. The HYD supply shutoff valve should be "OPEN."

    e. The ejector valve should be "OPEN" (amber indicating light "ON"). The pressure switch holds the ejector valve open.

    f. The bleed air shutoff valve should be "OPEN."

g. The manual fuel shutoff valve should be "OPEN." On the trainer this valve is connected by cable to the Number 1 (only) engine emergency fire handle. In the aircraft each fire handle is connected by cable to a manual fuel valve for that engine.

h. The ejector duct valve actuator (cooling air) should be "OPEN" or extended. This actuator will open or close a small door on the engine cowling for cooling purposes.

i. The fuel shutoff valve actuator should be extended (valve not shown on trainer).

> Note: Only the two way check valves are shown since tubing is not used on the trainer. Normally these two check valves are in the manifold tubing connecting the two fire bottles. The spring loaded "flappers" in the check valves position in response to the direction of agent flow.

> Note: The wiring for the system is routed through the two emergency shutdown relays on the lower right corner of the trainer.

6. To energize the engine emergency shutdown system, "pull" the engine Number 1 fire handle.

a. Check that all valves "close."

b. Ejector valve amber light should go "off" (indicator valve closed and pressure dropped).

c. HYD shutoff valve amber light should come "ON" (indicating valve has closed).

d. We now have fuel, hydraulic fluid, bleed air, and cooling air shut off from the Number 1 engine.

7. To energize the fire extinguishing system, press the "push to discharge" button which was uncovered when Number 1 handle was pulled.

a. With the bottle selector switch in "NORM," the circuit will fire the "NORM" squib in fire bottle Number 1 (check the red squib firing lights).

b. The fire bottle Number 1 red light on the annunciator panel should come "ON" (these two lights are connected to the pressure switch in the fire bottles; a pressure drop to 225 psi or below will turn on these lights). The pilot now knows that the agent in fire bottle Number 1 has been sent to engine Number 1.

8. If for some reason one bottle did not extinguish the fire in engine Number 1, the bottle selector switch would be positioned to "ALT" (flip this switch down). Now press the "press to discharge" button for engine Number 1 again.

a. The circuit will now fire the "alternate" squib in fire bottle Number 2 (check squib firing lights). The agent in this bottle will also go to engine Number 1.

b. The fire bottle Number 2 red light on the annunciator panel should come "ON." (Drop in pressure to 225 psi or lower turns on this light.)

c. If this firing sequence is not clear, use the wiring diagram on the trainer and trace the circuit out with a grease pencil. (Wiring diagrams are in the upper right hand corner of the trainer.)

9. To reset the trainer for another operation:

a. Place the bottle selector switch back to "NORM."

b. Push fire handle Number 1 back in.

c. Check that all valves return to the "OPEN" position.

d. The ejector valve amber light should be "ON" and the HYD shutoff valve amber light "OFF."

* e. Place the trainer power master switch "OFF" and then "ON" again to reset the squib firing and annunciator panel lights. (On the aircraft these bottles must be recharged to turn "OFF" the annunciator lights.)

10. For this check, assume the fire is in the Number 2 engine.

a. Pull the fire handle for engine Number 2. Check that all valves close.

b. Press the "push to discharge" button behind the Number 2 handle.

c. With the bottle selector switch in "NORM," the circuit will now fire the "NORM" squib in fire bottle Number 2. (Check squib firing lights.)

d. The fire bottle Number 2 light on the annunciator panel should come "ON."

11. If this did not extinguish the fire, bottle Number 1 can be used.

* a. Position the bottle selector switch to "ALT."

b. Press the "push to discharge" button again.

* c. The circuit will now fire the "alternate" squib in fire bottle Number 1 and send the agent to engine Number 2. (Check the squib firing lights.)

d. The fire bottle Number 1 light on the annunciator panel will now come "ON."

e. Check the wiring diagram on the trainer to see how this happens.

12. Shut the trainer down as follows:

a. Push engine Number 2 fire handle in.

b. Position the bottle selector switch back to "NORM."

c. Place the trainer power master switch "OFF."

d. Remove the trainer power cord from the 28V DC outlet and position it behind the trainer.

e. Fill out an AFTO Form 349 for the operational check.

13. Additional Information:

a. The complete operational checkout sequence for the fire extinguishing system is outlined in 1C-141A-2-7. Normally, the connector plugs are removed from the squibs and a test set is used to check the electrical circuit.

b. The only indicating lights found on the aircraft fire extinguishing system are the fire bottle lights on the annunciator panel. The squib firing and valve operation lights are on the trainer only. This completes the operational check of the fire extinguishing system. Check with your instructor before continuing.

Instructor Assists: _____ Instructor's Initials __________

PROJECT 3

Information

By now you should have inspected and operated the fire extinguishing trainer. You should have a good idea of how the system operates. In this project, you will troubleshoot the system by locating defects that are put in the system by trouble switches. Note that test jacks have been put in each circuit on the trainer. With test jacks, there is no need to take off the AN connector plugs to check a circuit.

When you check the various circuits, use a grease pencil to trace the circuit on the plastic covered wiring diagram. The diagram is on the trainer. This will keep you from checking the same circuit twice.

Procedures

1. Set up the trainer for normal operation (power switch ON and master switch ON).

2. Find trouble switch Number 3. The trouble switches are on the right side of the trainer.

3. Place this trouble switch to the IN position.

Warning: When a fire extinguishing system needs maintenance, be sure that the AN connector plugs have been taken off the firing squibs, before a multimeter is used. The battery in the meter has the current that would fire a squib. When a squib needs to be checked, use a meter that CANNOT give more than 35 milliamperes of current. Be sure to check the technical order for the aircraft on which you are working.

4. Pull the Number 1 fire handle. Check circuit indication.

5. Press the push to discharge button (located under the fire handle) for the Number 1 engine.

6. Watch the squib firing lights.

7. Since the circuit "A" squib firing light DID NOT come ON, check the trainer wiring diagram for test points.

8. Check the circuit with the multimeter.

Note: You can troubleshoot the trainer with power ON or OFF. Make sure you have the meter set correctly when making either a power ON or a power OFF check.

9. After the circuit is checked, you should have found that wire number 1W2B18 was OPEN. This wire is between the Number 1 engine discharge button and the bottle selector switch.

10. Mark the wiring diagram to show the problem. Use an "X" and the trouble switch number.

11. Use a 349 to write up the discrepancy and the corrective action and take time for troubleshooting and making the corrective action.

12. Place trouble switch number 3 to the OUT position.

13. Ask your instructor to assign you 5 problems. Troubleshoot these problems by following the ops check procedures in project 3.

14. Have the instructor check your answers before you start the next project.

Instructor Assists: 1. _____, 2. _____ Instructor Initials _____

PROJECT 4

Information

In this project. you will bench check fire extinguishing bottle squibs to find out if they are good. Use the figure on the last page of this book when making this check. The diagram will help you to find some of the components that are not labeled on the tester. Read all of the steps one time, then start the test.

Caution: The squib must always be placed in the agent container when a continuity check is made. If the meter should detonate the squib, the container would discharge the liquid agent.

Procedure

1. Check the condition of the squib tester before you use it.

a. First, be sure that the SHORTING BAR is put between the binding posts, located at the top of the tester.

Caution: Never press the OPERATING KEY when the shorting bar is not in place, or when the SPRING CLIP LEADS are not hooked to the squib. This could damage parts in the tester.

b. Set the OHMS DIGITAL DIAL to read all zeros by turning the DIGITAL DIAL KNOB counterclockwise (CCW).

c. Set the OHMS ADD SELECTOR SWITCH TO zero.

* d. Press the operating key and watch the pointer on the meter. If the pointer does not move, the tester circuit is good. If the pointer moves, there is an open in the tester circuit. Check with your instructor if the pointer moves.

2. Using the Squib tester.

a. Remove the shorting bar from between the two binding posts.

* b. The resistance value will vary with different squibs. The resistance value and tolerance of the squibs you will test is 2.30 ± 0.50 ohms. Set a resistance value of 2.30 ohms in the ohms digital dial by turning the digital dial knob clockwise (CW).

* c. Hook the spring clip leads to the AN connector plug located on the top of the tester.

d. Hook a spring clip lead to one of the pins of the AN connector on the squib under test. Hook the other lead to the ground terminal of the squib.

Note: Since you will check both the A and B circuits in each squib, it is not too important whether A or B is checked first.

* e. Press the operating key and watch the meter pointer. If the pointer moves, increase or decrease the ohms value you had set in the ohms digital dial. Keep adjusting until the meter pointer is centered on the red line of the meter scale.

f. With the operating key pressed, read the ohms digital dial. The reading should be 2.30 ± 0.50 ohms. If this is the reading, the squib is good. If the reading is not in tolerance, the squib is bad.

g. If the circuit proves to be good, remove the spring clip lead from the pin and connect it to the other pin to check that circuit.

h. Do steps d, e and f.

i. Write up the bench check on AFTO Forms 349.

EXAMPLE

Your instructor gave you a squib that has a resistance value and tolerance of 2.30 ± 0.50 ohms. Hook one lead to a pin of the squib and the other lead to the ground connection. Set the ohms add selector switch to zero (0). Then, set 2.30 ± 0.50 ohms in the digital dial and press the operating key. If you can center the meter pointer (red line) by adding or subtracting not more than 0.50 ohms, the squib is good. Do the above steps with the other circuit.

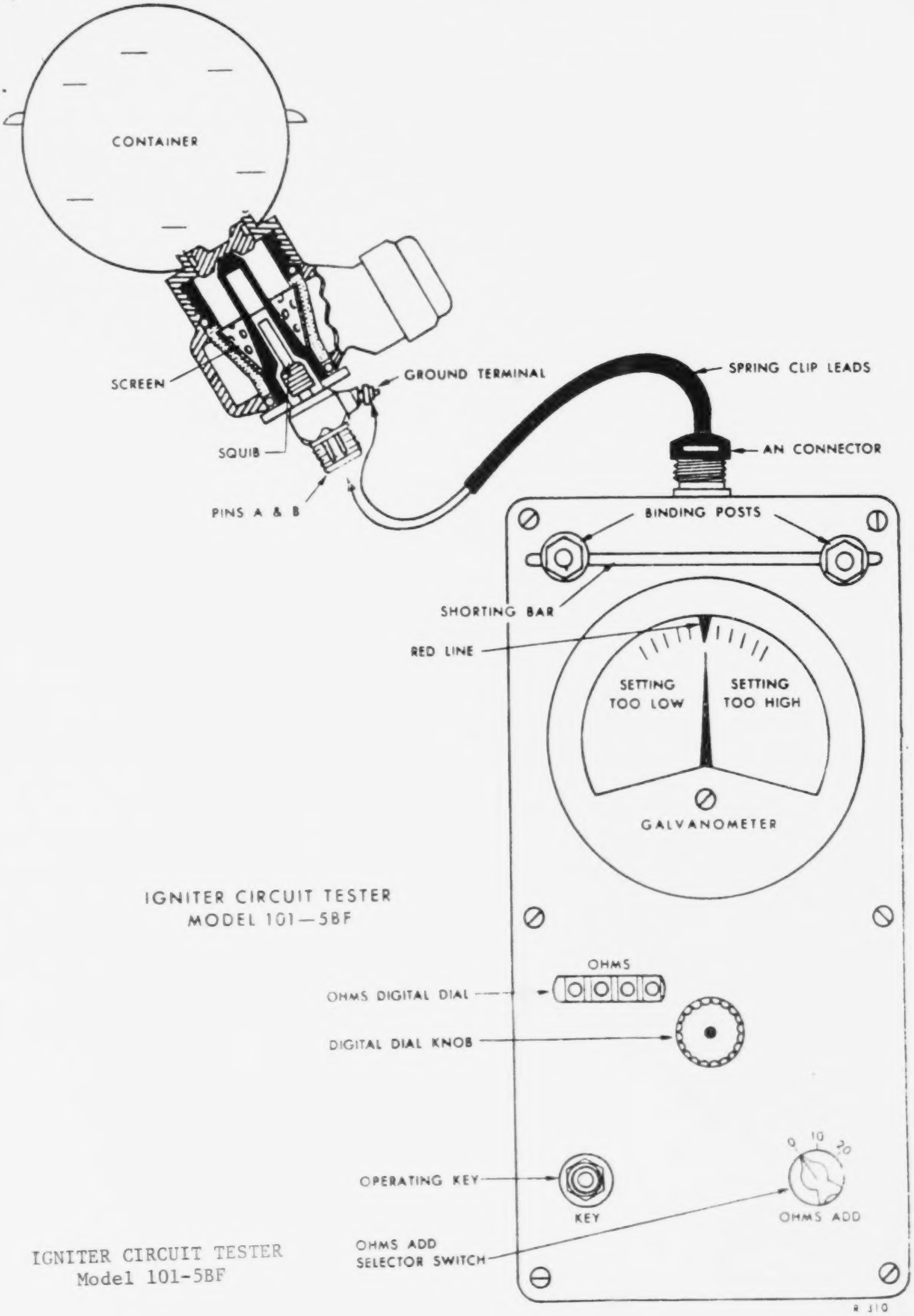
Note: The ohms add selector switch settings are in ten ohm increments. If the squib resistance is between 0 and 10 ohms, use the zero (0) setting of the switch. If the resistance is between 10 and 20 ohms, set the switch on 10. If the resistance is over 20 ohms, set the switch on 20.

3. Securing the squib tester.

Remove the test leads from the squib and tester and store them in the top of the tester cover. Replace the shoring bar between the binding posts and set the OHMS DIGITAL DIAL to read all zeros.

Instructor Initials ______

Instructor Assists: _____


CONTAINER
SCREEN
GROUND TERMINAL
SQUIB
PINS A & B
SPRING CLIP LEADS
AN CONNECTOR
BINDING POSTS
SHORTING BAR
RED LINE
SETTING TOO LOW
SETTING TOO HIGH
GALVANOMETER
IGNITER CIRCUIT TESTER
MODEL 101—5BF
OHMS
OHMS DIGITAL DIAL
DIGITAL DIAL KNOB
0
10
20
OPERATING KEY
KEY
OHMS ADD
OHMS ADD SELECTOR SWITCH
R 310

IGNITER CIRCUIT TESTER
Model 101-5BF

SERVICE TEST
STUDY GUIDE
C3ABR42331-SG-406A

Technical Training

Aircraft Environmental Systems Mechanic

AIRCRAFT FIRE EXTINGUISHING SYSTEMS
SAFETY, SERVICING AND REPAIR

4 June 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE.
DO NOT USE ON THE JOB.

OBJECTIVES

After completion of this programmed text, you will be able to:

1. State procedures for repairing components of a fire extinguishing system. A minimum of four out of five must be correct.

2. State procedures relating to the servicing of fire extinguishing systems. A minimum of four out of five must be correct.

3. Specify, without error, safety precautions involved in handling inert gases.

4. Specify, without error, safety precautions involved in handling toxic compounds.

5. Specify, without error, safety precautions involved in handling explosive squibs.

6. Specify, without error, safety precautions involved in handling high pressure gases.

INSTRUCTIONS

This study guide was designed to help you prepare for the measurement test. The information contained herein will support the instructors lesson and may be used to complete the progress check for the relating objectives.

OPR: 3370 TCHTG

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HAZARDS AND SAFETY PRECAUTIONS

Let's discuss some of the hazards and safety precautions that apply to working with and handling liquid fire extinguishing agents. We will discuss CB as the common agent but the same conditions apply to DB or any other liquid agent. CB is a volatile (evaporates rapidly) liquid, and its vapors are toxic. It should be used with adequate ventilation whenever possible. Avoid exposure to high concentrations of CB, for staggering, dizziness, lack of coordination, stupor, confusion, headache, nausea, or unconsciousness may result. CB is a very heavy gas and will settle to the floor in concentrations (or pools). Because it is so heavy, it does not mix with air easily and can become a health hazard if allowed to concentrate. If overexposure is noted, leave the area at once. If this is impossible, use an oxygen or air supplying mask. After overexposure, report to first aid immediately. Personnel regularly exposed to CB will be given a medical examination at intervals set up by the base hospital.

The nitrogen used in the recharging setup is stored in the bottle under high pressure. Because of this, ensure you follow all the safety procedures you learned about high pressure cylinders. This high pressure gas can cause body and property damage if not handled correctly. Do not allow the cylinder to fall over and do not "horseplay" with the cylinder or the gas coming out of it. Do not point the servicing hose at yourself or someone else. The high pressure gas can damage skin, or put out an eye.

BALE TEST

Besides producing toxic vapors, CB is also dangerous in another respect. Since it is designed to keep oxygen from a fire, it will keep the oxygen from any enclosed area. This is the reason for having a well ventilated room when handling CB. If your CB work area becomes contaminated with a high concentration of CB, a "Bale Test" will be done before reentering the area. This test is done by the base medical office.

CONTAINER WEIGHT CHECK

In previous lessons we talked about aircraft liquid agent bottles or containers. We said that the bottles or cylinders are filled by weight and hold pressure. We also said that dry nitrogen (N_2) is added to the agent to help in expelling it from the container at low temperatures.

At various times as shown by aircraft inspection TOs, these bottles or cylinders are removed from the aircraft and weight check is done.

The weight of the agent and of the bottles is stenciled on the bottle, in the same way life raft cylinders are. If the bottle does not meet the weight stenciled on it, the bottle must be serviced. At the same time, the pressure on the pressure gage is checked. If the pressure is not within limits, nitrogen (N_2) must be added to bring the pressure up to its correct level. If servicing is required, this task will most likely fall on the Environmental Systems Shop.

SELECT THE FOLLOWING STATEMENT(S) THAT IS/ARE TRUE.

____ 1. Aircraft fire bottles are filled by weight.

____ 2. Dry nitrogen is added to all aircraft fire bottles.

____ 3. A weight check is done with the bottle installed in the aircraft.

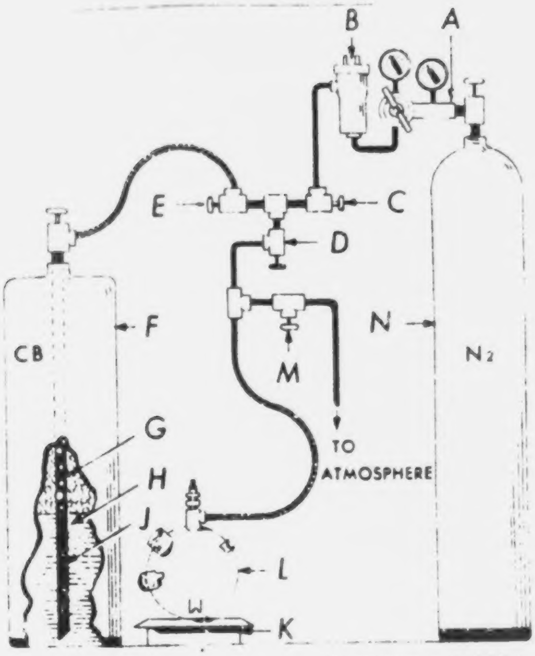
____ 4. Your shop may be responsible for recharging aircraft fire bottles.

RECHARGE SETUP

Shown in figure 1 is a typical recharge setup for recharging aircraft CB spheres. The two agents most widely used are chlorobromomethane (CB) and dibromodifluoromethane (DB). Note in the illustration that the CB storage cylinder (F), has a syphon tube (J) and stands with the valve end up. The CB storage cylinder is pressurized with nitrogen (G) which pushes the CB out the syphon tube (J) and into the sphere (L).

On the other side of the setup, we have the nitrogen supply cylinder (N). Nitrogen is drawn from the supply cylinder, through the pressure regulator (A) and through the purifier unit (B) to the aircraft sphere (L) which is mounted on the scales (K). The purifier assembly is not a mandatory item on the liquid agent setup.

In the shop, you will find only one liquid agent recharging setup. This is because of cost. Regardless of what type of setup you use, it will be used for all liquid agent recharging. There is only one requirement for using a single setup for different agents. The setup must be purged with compressed air when you change from one agent to another. Normally a shop only services one type of agent.



A. PRESSURE REGULATOR
B. PURIFIER ASSEMBLY
C. MANIFOLD VALVE (NITROGEN)
D. MANIFOLD VALVE
E. MANIFOLD VALVE (LIQUID AGENT)
F. CYLINDER (LIQUID AGENT)
G. GAS PRESSURE (NITROGEN)
H. LIQUID AGENT
J. SYPHON TUBE
K. SCALE
L. FIRE EXTINGUISHER
M. MANIFOLD VALVE (PRESSURE RELIEF)
N. NITROGEN SUPPLY CYLINDER

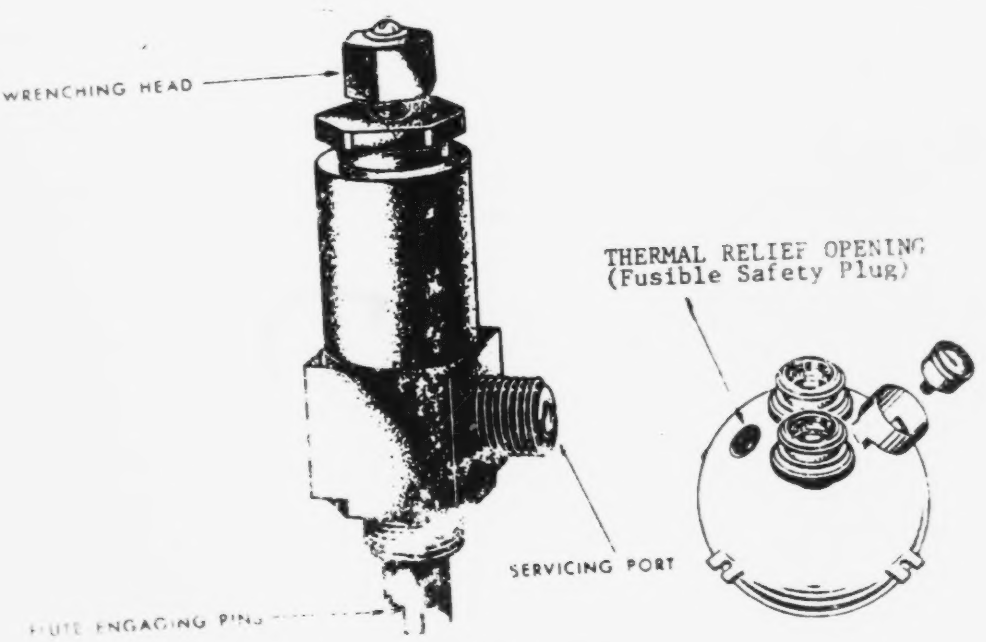
CB (Chlorobromomethane Recharge Setup.

Figure 1.

CHARGING BONNET

The first step in recharging liquid agent containers is to provide a method of attaching a charging line to the container. Liquid agent containers are recharged through the thermal relief (fusible safety plug) opening. To do recharging, a special charging bonnet is necessary for each different type of container. The charging bonnet is used to unseat the thermal relief device without actually removing the relief device from the container.

Figure 2 shows one type of liquid agent container charging bonnet. Notice that the charging bonnet has a wrenching head at the top. It also has pins at the bottom to engage flutes in the thermal relief device (safety plug) of the type shown in figure 2. After you screw the charging bonnet into place, use the bonnet wrenching head to back off the safety plug slightly so that the agent can enter the container. Carefully follow the correct procedures in using a charging bonnet. For example, you must screw the bonnet firmly into the container to prevent leakage between the bonnet and the container. Also, you must back off the safety plug only the specified number of turns. The plug threads may be damaged if the plug backs against the charging bonnet. If the plug threads are damaged in the charging process, the plug may separate from the container with explosive force after the charging bonnet is removed. Besides the charging bonnet, you still need certain other equipment to recharge a liquid agent container.


WRENCHING HEAD
THERMAL RELIEF OPENING
(Fusible Safety Plug)
SERVICING PORT
FLUTE ENGAGING PINS

CHARGING BONNET

Figure 2.

CB RECHARGING

Recharging equipment requirements vary slightly for the different types of liquid agents. There is a common requirement however, for all of the agents. In addition to a supply of the agent itself, you must have a supply of pressurized nitrogen. The nitrogen is used for two different purposes, as you will see. We shall discuss the recharging setup for CB.

CB recharging. Figure 1 shows a recharge setup for CB. Notice that the figure shows a liquid agent supply cylinder (F), a nitrogen supply cylinder (M), connected through various valves, and a purifier (filter) (B), to the fire extinguisher container (K). The connection to the container is made through a charging bonnet which was talked about is the last frame. The container (K) rests on the scale (J) so that the weight of the added agent can be measured. The CB has no pressure of its own; so it must be pressurized with nitrogen to force the agent out of the supply cylinder. You do this by opening two valves (C and E) and adjusting the pressure regulator assembly (A) to the proper value. Now we have a word of caution. Every liquid agent supply cylinder has a pressure limit that must not be exceeded. Failure to properly control the amount of pressure applied to the agent supply cylinder may cause this cylinder to explode. You must compare the recommended technical order pressure with the ICC rating on the neck of the cylinder. Never exceed the maximum pressure indicated by the ICC rating stamped into the cylinder.

After the agent supply cylinder has been pressurized, close the nitrogen manifold valve (C) and open the valve (D) to the fire extinguisher (K). Use the nitrogen pressure to transfer the specified amount (by weight) of the agent to the fire extinguisher container. After the correct amount of agent has been transferred to the container, pressurize the container with nitrogen. Even though nitrogen is not greatly affected by temperature changes, it is affected to some extent. When the room temperature is high, for example, the nitrogen in the supply cylinder has expanded. Therefore, a higher nitrogen pressure must be added to the liquid agent container to compensate for the pressure decrease that occurs when the temperature decreases. The technical order for the particular container lists the pressures to which the container must be serviced under varying temperature conditions.

After completing the charging process, you must bleed off the trapped agent and nitrogen in the charging lines. This is done by opening the bleed-off valve leading to the atmosphere (L). Again, you have to comply with safety precautions. The bleed line must dump the agent of an unoccupied area. Also as with the CO_2 recharge setup, you must see that the room is well ventilated if you use the recharge set indoors.

CLEANING SYSTEM

Most of the repair work on fire extinguishing systems is repairing the container after it has been used, cleaning the agent off the plane and engine, and replacing squibs due to time change or having been fired.

CB liquid and its vapors speed up corrosion of metals. Its corrosive action is increased by the presence of moisture. DB is a little less corrosive than CB, but it also contributes to corrosion. These agents damage the coatings and sealants on tubing and all parts they come in contact with. Thus all equipment soiled with these liquid agents should be cleaned as soon as possible after exposure. At no time should the residue from the agent be allowed to remain on the equipment for a period over 4 hours. After a fire has been put out, purge the area and plumbing with compressed dry air or nitrogen. Wash all surfaces with solvent (PD-680): then wash again with a solution of 10 percent sodium bicarbonate in water. Allow solution to remain on surface until all bubbling stops. Then remove the solution by wiping with a damp sponge or cloth, rinse with water, and dry.

SQUIBS (CARTRIDGES)

The explosive cartridge requires a large part of the maintenance of a liquid agent fire extinguishing system. You cannot operate the release mechanism to check it out. However, you must check it periodically to make sure that it will work when needed. You can do this by making a continuity check of the cartridge firing circuit, including the cartridge itself. This is where the difficulty arises. An ordinary ohmmeter or continuity checking device must not be used for the check. Ordinary continuity checking devices cause enough current flow to fire the cartridge. The maintenance technical order for the particular fire extinguisher system specifies the continuity checking device to be used for that system.

CONTINUITY TEST

First, you should never make a continuity test on a cartridge that is not physically contained in some way. If you make the test with the cartridge installed in the bonnet, while the bonnet is attached to the agent container, you will have no problem. If the cartridge accidentally fires, the agent will be released but the cartridge will not hurt you. However, you may have to do a continuity check on a cartridge that is not installed in the aircraft fire extinguisher system. If you bench-check a cartridge for continuity, you must put it in a suitable fixture as shown by the applicable technical order. This fixture is made to give protection for you in case the cartridge accidentally discharges. The times at which you perform continuity checks vary according to the aircraft involved.

When a continuity test shows that a cartridge is bad, remove and replace it. However, do not throw the old cartridge into a trash can. Your Air Force base has an organized, explosive-material disposal unit that will handle the unwanted cartridge.

1491

CONTAINER REPAIR

After the container has been used, it must be repaired. Normally this means replacing the O-ring, frangible disc, squib and strainer. Then the bottle must be recharged, leak checked and reinstalled in the aircraft.

At some time, you will also have to replace a directional valve. This does not occur very often if proper maintenance including cleaning of the system takes place.

The pressure gage on the container may also need to be replaced at times. Be sure that you bleed off the nitrogen charge in the bottle before you try to take the gage off. The gage simply screws out of the bottle and a new one screws in. Remember to repressurize the bottle with nitrogen and leak check the pressure gage before you put the bottle back on the aircraft.

1492

SERVICE TEST
PROGRAMMED TEXT
C3ABR42331-PT-407

Technical Training

Aircraft Environmental Systems Mechanic

LIQUID REFRIGERANT SYSTEM SAFETY

20 August 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE

DO NOT USE ON THE JOB

OBJECTIVE

1. Using a refrigeration trainer, inspection workcard, and workbook, inspect a liquid cycle refrigeration system. Locate a minimum of two discrepancies and record on AFTO form 349. A maximum of one instructor assist is allowed. Apply safety precautions without error.

2. Using a refrigeration trainer, manifold gage, workbook, and safety equipment, perform an operational check of a liquid cycle refrigeration system. A maximum of two instructor assists is allowed. Apply safety precautions without error.

INSTRUCTIONS

This programmed text is presented in small steps called "Frames". The material Contained herein will support objectives given during class or lab. At the end of some of the frames you may be asked to complete the statements that are TRUE. The answers can be found on the next page. Read the material in the frames carefully then select the true statements. If you are correct, proceed on to the next frame. If you are wrong or in doubt, restudey the information until you can correctly identify the true statements.

104

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3370 TCHTG/TTGU-P - 300; DAV - 1

Frame 1

Refrigerants can come in differant amounts from a railroad carload size to a 1-pound can. However, most of the refrigerant that the Air Force gets is in 145-pound cylinders. These cylinders are too heavy for the serviceman to move from place to place, so the refrigerant must be transferred to smaller containers. This is done be obtaining a small cylinder designed for the particular gas that is to be transferred. If you are ever tasked to do this NEVER 85% liquid full, and always wear protective equipment when transferring liquid.

NO RESPONSE NECESSARY

BEST COPY AVAILABLE

Let's look at some of the DOs and DONTs while handling refrigerant cylinders.

1. Never drop cylinders or permit them to strike each other violently.
2. Never use a lifting magnet or a sling when handling cylinders. A crane may be used when a safe cradle or platform is provided to hold the cylinders.
3. Keep cylinder valve caps on at all times except when the cylinders are in use.
4. Never fill a refrigerant cylinder completely full of refrigerant. The safe limit is 85 percent full. Overfilled cylinders are apt to burst from expanding gases causing increased pressure.
5. Never mix gases in a cylinder.
6. Don't use cylinders for a support or roller-cylinders are made to hold gas.
7. Never tamper with the safety device on a cylinder.
8. Open cylinder valves slowly and use a cylinder valve wrench. Never use a pipe wrench for this purpose.
9. Never force misfitting connections; make sure that the threads of regulators and unions are the same as those on the cylinder outlet.
10. Never attempt to repair or alter a cylinder or valve.
11. Never store cylinders near flammables.
12. Always keep cylinders stored in a cool place away from direct sun rays if possible and fully secured in place.
13. Do not store full and empty refrigerant cylinders together. They should be stored in differant sections of the shop to avoid confusion.
14. Always insure that gas cylinders are secured in place both when empty and filled.

NO RESPONSE NECESSARY

Frame 3

As stated before, you should always wear protective equipment while changing or transferring refrigerant. However, if something happens when you do not have the protective equipment on and the refrigerant comes in contact with your skin or eyes, you should know the first aid that will help you. If the refrigerant comes in contact with your eyes, bathe them in a 2-percent boric-acid solution or in mineral oil. For frostbite on the skin, wash the area with cold water and massage around the area until circulation is restored. Do not disturb the frost blisters. Always seek medical aid as soon as possible.

NO RESPONSE NECESSARY

WORKBOOK

C3ABR42331 000-WB-407

Technical Training

Aircraft Environmental Systems Mechanic

LIQUID REFRIGERANT SYSTEM MAINTENANCE

11 September 1984

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

Designed for ATC Course Use.

Do Not Use on the Job.

ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331 000-WB-407

LIQUID REFRIGERANT SYSTEM MAINTENANCE

OBJECTIVES

Using a refrigeration trainer, inspection workcard and workbook, inspect a liquid cycle refrigeration system. A maximum of one instructor assist is allowed. Apply safety precautions without error.

Using a refrigeration trainer, manifold gage, workbook and safety equipment, perform an operational check of a liquid cycle refrigeration system. A maximum of two instructor assists are allowed. Apply safety precautions without error.

Given a liquid cycle, refrigeration schematic and malfunctions, correctly identify four out of five causes.

EQUIPMENT

Inspection Workcard
O-6 Code Manual
AFTO Form 349
Manifold Gage Assembly
Trainer, Liquid Refrigerant
Eye Protection

INTRODUCTION

This workbook deals with inspecting, operating and performing a hand temperature check of a refrigeration system at strategic points. Throughout the procedures, you will be required to have the instructor check your work and initial the workbook.

Note: Procedures that have an asterisk (*) in front of them are considered to be the hardest tasks. Instructor assists may be given on them as shown in objectives.

Supersedes C3ABR42331-WB-407, 18 April 1983.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500, DAV - 1

SAFETY

Whenever you are working on a refrigeration system, you must follow all safety rules. Never store liquid refrigerant cylinders in an area that will exceed 125°F, and always insure that the room the cylinders are in or used in has adequate ventilation. Never expose refrigerant to an open flame, because it will result in the making of a poisonous gas. Refrigeration systems are under high pressure, so make sure the system does not have pressure on it before starting any maintenance. When operational checking or performing maintenance on a refrigeration system, make sure you put on eye protection (either goggles or a face shield), because refrigerant is very cold and will freeze any part of your body it comes into contact with.

INSPECTION

Locate the components that are on your inspection workcard and write up the minimum of two discrepancies on AFTO Forms 349.

Instructor Assists ____________

Instructor's Initials ____________

Before we can go into the operation procedures for the liquid refrigeration trainer, we need to go over the operation of the manifold gages so you can understand their use.

1. The manifold gage set, that you have for the operation of this refrigeration unit, is important for proper troubleshooting and to tell you if you have proper operating pressures. The manifold assembly consists of two gages - a red high pressure and a blue low pressure (locate the gages on the trainer). The high pressure gage will tell you the high side system pressure by reading the outer black scale from 0 to 500 psi. The low pressure gage will tell you the pressure on the low side of the system by reading the black scale from 0 to 250 psi. Also on this gage assembly are three service hoses. The red hose is hooked up to the compressor discharge valve and the blue hose is hooked up to the compressor suction service valve. The yellow hose is used when you want to drain the system pressure to do maintenance. It is also used when the system needs to be evacuated or serviced.

2. Now look carefully at the faces of your manifold gage assembly. You will see three red scales on each gage. Each scale is used for the type of refrigerant you are using, for instance, R-502, R-12, R-22. When the system is running and you have a pressure reading of 25 psi on the low pressure gage (blue), you can see the temperature at that pressure is 25°F. The high pressure gage will also tell you the temperature at the corresponding pressure. If you have 125 psi, the temperature is 105°F. When you start on the operation of this trainer, you will see how the gage assembly works.

As you complete each step, place your initials in the space provided, next to the number of each step.

_____ 1. Locate on the trainer and place a check in the blank below for all components that are in the high pressure side of the system.

_____ Evaporator _____ Compressor _____ Condenser

_____ Drier _____ Suction Service Valve

_____ Compressor Discharge Valve _____ Expansion Valve Inlet

_____ Expansion Valve Outlet

Instructor's Initials __________

_____ 1a. Locate on the trainer and place a check in the blank below for all components that are in the low pressure side of the system.

_____ Evaporator _____ Compressor _____ Condenser

_____ Drier _____ Suction Service Valve

_____ Compressor Discharge Valve _____ Expansion Valve Inlet

_____ Expansion Valve Outlet

Instructor's Initials __________

_____ 2. Locate the trainer power switch in the upper right hand corner of the trainer. (OFF position)

_____ 3. Locate the trainer power cord on the back of the trainer and connect the cord to the 110/115 VAC wall outlet. The trainer power light should come on.

_____ 4. Place the trainer power switch to the ON position and watch the sight glass. Liquid refrigerant (R-12) will rise in the sight glass. Notice the green dot in the glass; this is a moisture indicator to let you know if the system has moisture in it. The green dot will turn yellow when there is moisture present.

Note: Moisture in refrigerant systems will cause system malfunction. Moisture forms ice in the low pressure side of the system and could block flow to the evaporator by freezing up the expansion valve. This would be noticed by reading the pressure on the low pressure gage. The pressure would show a steady decrease in system pressure.

_____ 4a. The temperature inside the cabinet is _____°F.

Instructor's Initials __________

_____ 5. Operate system for ten minutes and observe the low pressure and high pressure gages. The high pressure gage will tell you what the system pressure on the high side (coming out of the compressor discharge valve) is. Remember, the compressor increases the pressure and temperature. What is the pressure on the high pressure gage? ____ psi. The temperature is ____ °F.

Instructor's Initials ____________

_____ 6. Now read the low pressure gage that is hooked up to the suction service valve. This gage tells you the pressure in the low pressure side of the system that is being sucked into the compressor. What is the pressure? ______. What is the temperature? _____.

Instructor's Initials ____________

Note: You are now going to perform a hand temperature check by feeling the system components and tubing. You can tell a lot just by feeling the lines on any refrigeration system, if it is operating properly or not.

_____ 7. Put your hand around the compressor discharge valve and notice the temperature. It should be hot. If you look at the high pressure gage, you can find the temperature by reading the red inner scale. The system works with R-12, so read the middle scale and the corresponding pressure will tell you the temperature.

_____ 8. The first stage in cooling the R-12, takes place in the condenser. You cannot feel the condenser, however, you can do a visual check. The hot gas, which is high pressure, is cooled by conduction. (Remember that heat travels from a warm substance to a cold substance.) This changes the gas to a high pressure liquid.

_____ 9. Now feel the black receiver and notice the temperature. It should be warm to the touch. The receiver stores and keeps liquid R-12 under high pressure.

_____10. Now feel the line going to the dehydrator or drier. It should be warm also. If you were to feel a cold spot in this line, that would indicate that there is a restriction, causing a pressure drop.

_____11. Put your hand around the drier (dehydrator). It should be warm to the touch. If you found it to be cool, that is a sign that the filter has absorbed too much moisture and contamination and is causing a pressure drop on the outlet side of the drier. This reduces the cooling effect where it is needed.

_____12. Look into the sight glass. If you see bubbles or a low level of fluid, that is letting you know that you are low on R-12, which would cause the system not to operate properly. Check the green dot also. Is the sight glass (1) clear? ______:
(2) half full? _____; (3) full? _____; (4) bubbles? _____
(5) empty? _____. Is the dot green? _____; yellow? _____

Instructor's Initials ____________

_____ 13. Now check the expansion valve. Feel the inlet line. Is it very warm? Yes _____ No _____. It should be warm. Now feel the outlet line going to the evaporator.. Is it very cold? The expansion valve meters the flow of R-12 into the evaporator. The pressure at the inlet is high with warm temperature, the outlet is cold with low pressure.

Note: The tubing that you see coming out of the valve is a sensing device to control the right amount of liquid to the evaporator. It is attached to the outlet of the evaporator, it is called a thermal bulb, and senses temperature. If the temperature is too cold, it will tell the expansion valve to close. If the temperature gets too hot, it will tell the expansion valve to open.

*_____ 14. The evaporator is where cooling the ambient air takes place. It also changes the R-12 from a low pressure liquid to a low pressure gas. (Remember that heat moves from a warmer substance to a colder one.) The R-12 is absorbing heat, which will cause the R-12 to change to a gas. What is the temperature of the outlet of the evaporator? _____ °F.

Instructor's Initials _____________

_____ 15. Now put your hand around the suction line leaving the evaporator, going to the suction service valve. Is it cold? _____ or is it hot? _____. In this line there is low pressure gas going to the compressor and its temperature is cold.

*_____ 16. Read the pressure and temperature of the low pressure gas on the compound gage (blue) and record it. _____ psi _____ temperature.

_____ 16a. Record the temperature in the cabinet _____ °F.

Instructor's Initials _____________

_____ 17. Now you are back at the compressor. Put your hand on top of the compressor. Do you feel the two different temperatures? (Cold on the left and hot on the right.) If there was not a difference between the two, that is a sign that there is a problem with the compressor, which would affect the whole operation of the system.

_____ 17a. Turn off trainer power switch. Unplug the trainer from the outlet on the wall.

Instructor's Initials _____________

Instructor Assists 1. _____
2. _____

On this page is a schematic of a basic liquid cycle refrigeration system. Read each procedure and comply with it before going to the next step.

1. Color code the key that is provided on the schematic, with four different colors.

2. Name the system components in the blanks provided below.

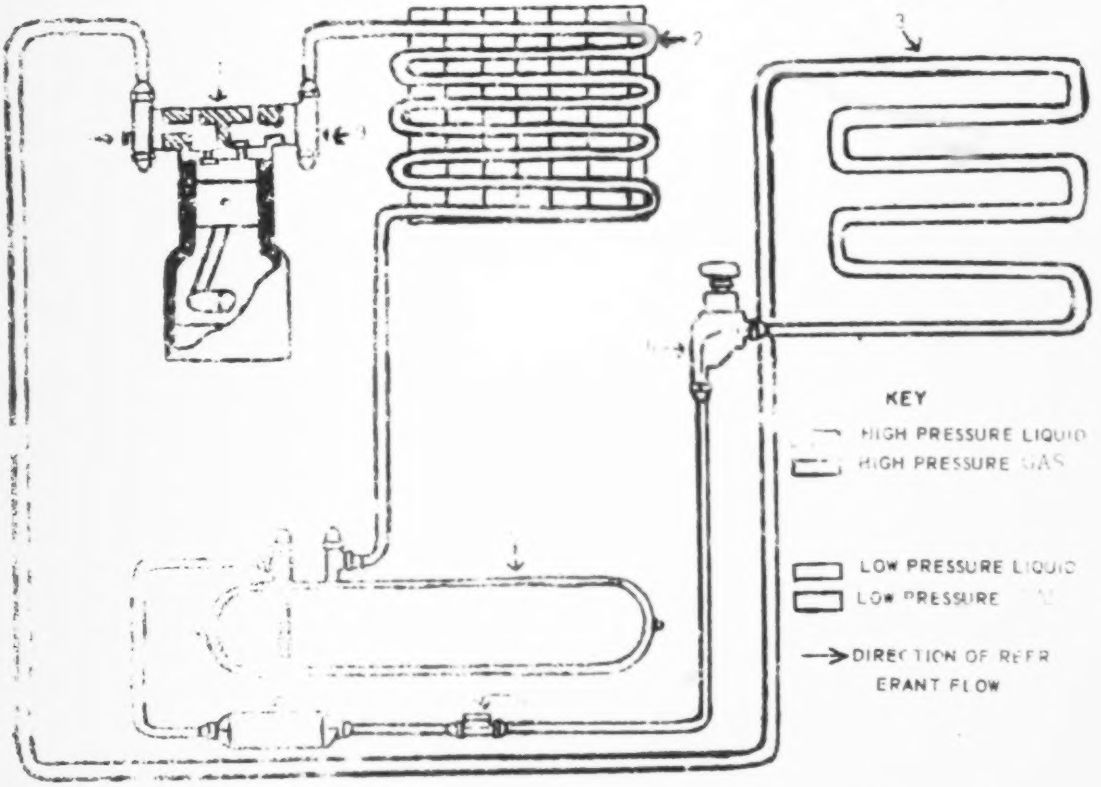
3. Place a check mark in the correct space next to the name of each component to show whether the component is in the high pressure (H/P) side or the low pressure (L/P) side.

4. Using the color code key that you made. color in the diagram to show the changes in state and temperature that occurs in the system.

5. Using arrows, show the direction of flow through the system.

6. Have your instructor check your work.

Instructor's Initials ___________


2
3
KEY
HIGH PRESSURE LIQUID
HIGH PRESSURE GAS
LOW PRESSURE LIQUID
LOW PRESSURE
DIRECTION OF REFRERANT FLOW

COMPONENT NAME	H/P	L/P	COMPONENT NAME	H/P	L/P
1. __________	______	______	6. __________	______	______
2. __________	______	______	7. __________	______	______
3. __________	______	______	8. __________	______	______
4. __________	______	______	9. __________	______	______
5. __________	______	______	10. __________	______	______

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WORKBOOK
C3ABR42331-WB-407

Technical Training

Aircraft Environmental Systems Mechanic

LIQUID REFRIGERANT SYSTEM MAINTENANCE

18 April 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE.

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ATC FORM 214 (JAN 76) OBSOLETES ATC FORMS 214, MAY 69, 522, NOV 63 AND 523, MAY 71. STANDARD COVERSHEET

Environmental Pneudraulics Branch
Chanute AFB, Illinois

C3ABR42331-WB-407

LIQUID REFRIGERANT SYSTEM MAINTENANCE

OBJECTIVES

Using a refrigeration trainer, inspection workcard and workbook, inspect a liquid cycle refrigeration system. Locate and record a minimum of two discrepancies on AFTO Forms 349. A maximum of one instructor assist is allowed. Apply safety precautions without error.

Using a refrigeration trainer, manifold gage, workbook and safety equipment, perform an operational check of a liquid cycle refrigeration system. A maximum of two instructor assists are allowed. Apply safety precautions without error.

Given a liquid cycle, refrigeration schematic and malfunctions, correctly identify four out of five causes.

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0-[illegible] Code Manual
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Manifold Gage Assembly
Trainer, Liquid Refrigerant
Eye Protection

INTRODUCTION

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Supersedes C3ABR42331-WB-407, 4 November 1982.
OPR: 3370 TCHTG
DISTRIBUTION: X
3370 TCHTG/TTGU-P - 500; DAV - 1

SAFETY

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Locate the components that are on your inspection workcard and write up a minimum of two discrepancies on AFTO Forms 349.

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Before we can go into the operation procedures for the liquid refrigeration trainer, we need to go over the operation of the manifold gages so you can understand their use.

The manifold gauge set, that you have for the operation of this refrigeration unit, is important for proper troubleshooting and to tell you if you have proper operating pressures. The manifold assembly consists of two gages - a red high pressure and a blue low pressure (locate the gages on the trainer). The high pressure gage will tell you the high side system pressure by reading the outer black scale from 0 to 500 psi. The low pressure gage will tell you the pressure on the low side of the system by reading the black scale from 0 to 250 psi. Also on this gage assembly are three service hoses. The red hose is hooked up to the compressor discharge valve and the blue hose is hooked up to the compressor suction service valve. The yellow hose is used when you want to drain the system pressure to do maintenance. It is also used when the system needs to be evacuated or serviced.

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BEST COPY AVAILABLE

As you complete each step, place your initials in the space provided, next to the number of each step.

____ 1. Locate on the trainer and place a check in the blank below for all components that are in the high pressure side of the system.

____ Evaporator ____ Compressor ____ Condenser

____ Drier ____ Suction Service Valve

____ Compressor Discharge Valve ____ Expansion Valve Inlet

____ Expansion Valve Outlet

Instructor's Initials ________

____ 1a. Locate on the trainer and place a check in the blank below for all components that are in the low pressure side of the system.

____ Evaporator ____ Compressor ____ Condenser

____ Drier ____ Suction Service Valve

____ Compressor Discharge Valve ____ Expansion Valve Inlet

____ Expansion Valve Outlet

Instructor's Initials ________

____ 2. Locate the trainer power switch in the upper right hand corner of the trainer. (OFF position)

____ 3. Locate the trainer power cord on the back of the trainer and connect the cord to the 110/115 VAC wall outlet. The trainer power light should come on.

____ 4. Place the trainer power switch to the ON position and watch the sight glass. Liquid Refrigerant (R-12) will rise in the sight glass. Notice the green dot in the glass; this is a moisture indicator to let you know if the system has moisture in it. The green dot will turn yellow when there is moisture present.

Note: Moisture in refrigerant systems will cause system malfunction. Moisture forms ice in the low presure side of the system and could block flow to the evaporator by freezing up the expansion valve. This would be noticed by reading the pressure on the low pressure gage. The pressure would show a steady decrease in system pressure.

____ 4a. The temperature inside the cabinet is ______°F.

Instructor's Initials ________

____ 5. Operate system for ten minutes and observe the low pressure and high pressure gages. The high pressure gage will tell you what the system pressure on the high side (coming out of the compressor discharge valve) is. Remember, the compressor increases the pressure and temperature. What is the pressure on the high pressure gage? ______ psi. The temperature is ______°F.

Instructor's Initials ___________

____ 6. Now read the low pressure gage that is hooked up to the suction service valve. This gage tells you the pressure in the low pressure side of the system that is being sucked into the compressor. What is the pressure? _______. What is the temperature? _______.

Instructor's Initials ___________

Note: You are now going to perform a hand temperature check by feeling the system components and tubing. You can tell a lot just by feeling the lines on any refrigeration system, if it is operating properly or not.

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____ 8. The first stage in cooling the R-12, takes place in the condenser. You cannot feel the condenser, however, you can do a visual check. The hot gas, which is high pressure, is cooled by conduction. (Remember that heat travels from a warm substance to a cold substance.) This changes the gas to a high pressure liquid.

____ 9. Now feel the black receiver and notice the temperature. It should be warm to the touch. The receiver stores and keeps liquid R-12 under high pressure.

____ 10. Now feel the line going to the dehydrator or drier. It should be warm also. If you were to feel a cold spot in this line, that would indicate that there is a restriction, causing a pressure drop.

____ 11. Put your hand around the drier (dehydrator). It should be warm to the touch. If you found it to be cool, that is a sign that the filter has absorbed too much moisture and contamination and is causing a pressure drop on the outlet side of the drier. This reduces the cooling effect where it is needed.

BEST COPY AVAILABLE

____ 12. Look into the sight glass. If you see bubbles or a low level of fluid, that is letting you know that you are low on R-12, which would cause the system not to operate properly. Check the green dot also. Is the sight glass (1) clear? ____
(2) half full? ____; (3) full? ____; (4) bubbles? ____
(5) empty? ____.
Is the dot green? ______; yellow? ________.

Instructor's Initials ________

____ 13. Now check the expansion valve. Feel the inlet line. Is is very warm? Yes ___ No ___. It should be warm. Now feel the outlet line going to the Evaporator. Is it very cold? The expansion valve meters the flow of R-12 into the evaporator. The pressure at the inlet is high with warm temperature, the outlet is cold with low pressure.

Note. The tubing that you see coming out of the valve is a sensing device to control the right amount of liquid to the evaporator. It is attached to the outlet of the evaporator, it is called a thermal bulb, and senses temperature. If the temperature is too cold, it will tell the expansion valve to close. If the temperature gets too hot, it will tell the expansion valve to open.

____ 14. The evaporator is where cooling the ambient air takes place. It also changes the R-12 from a low pressure liquid to a low pressure gas. (Remember that heat moves from a warmer substance to a colder one.) The R-12 is absorbing heat, which will cause the R-12 to change to a gas. What is the temperature of the outlet of the evaporator? ______°F.

Instructor's Initials ________

____ 15. Now put your hand around the suction line leaving the evaporator, going to the suction service valve. Is it cold? ____ or is it hot? ______. In this line there is low pressure gas going to the compressor and its temperature is cold.

____ 16. Read the pressure and temperature of the low pressure gas on the compound gage (blue) and record it. ____psi ____ temperature

____ 16a. Record the temperature in the cabinet ____°F.

Instructor's Initials ________

17. Now you are back at the compressor. Put your hand on top of the compressor. Do you feel the two different temperatures? (cold on the left and hot on the right). If there was not a difference between the two, that is a sign that there is a problem with the compressor, which would affect the whole operation of the system.

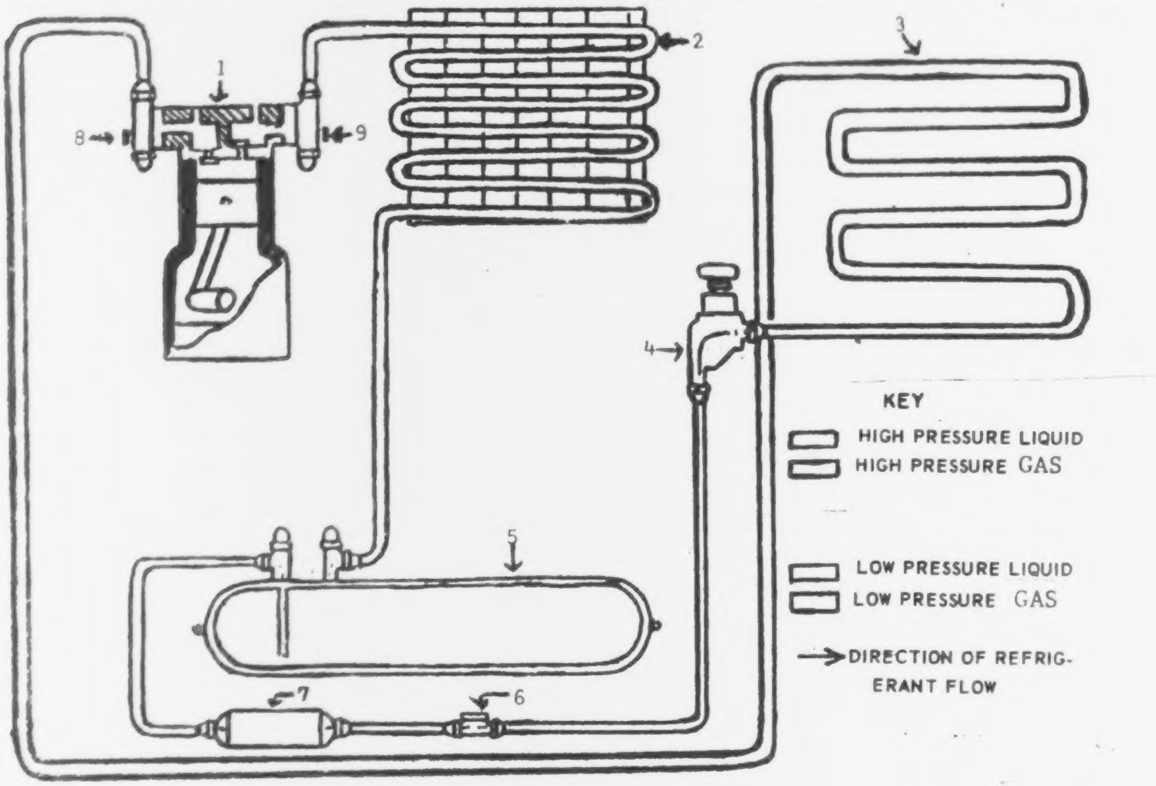
____ 17a. Turn off trainer power switch. Unplug the trainer from the outlet on the wall.

Instructor's Initials ________

On this page is a schematic of a basic liquid cycle refrigeration system. Read each procedure and comply with it before going to the next step.

1. Color code the key that is provided on the schematic, with four different colors.
2. Name the system components in the blanks provided below.
3. Place a checkmark in the correct space next to the name of each component to show whether the component is in the high pressure (H/P) side or the low pressure (L/P) side.
4. Using the color code key that you made, color in the diagram to show the changes in state and temperature that occurs in the system.
5. Using arrows, show the direction of flow through the system.
6. Have your instructor check your work.

Instructor's Initials ________


1
2
3
4
5
6
7
8
9
KEY
▭ HIGH PRESSURE LIQUID
▭ HIGH PRESSURE GAS
▭ LOW PRESSURE LIQUID
▭ LOW PRESSURE GAS
→ DIRECTION OF REFRIGERANT FLOW

COMPONENT NAME	H/P	L/P	COMPONENT NAME	H/P	L/P
1. ________	____	____	6. ________	____	____
2. ________	____	____	7. ________	____	____
3. ________	____	____	8. ________	____	____
4. ________	____	____	9. ________	____	____
5. ________	____	____	10. ________	____	____

1511

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PROGRAMMED TEXT
C3ABR42331-PT-408

Technical Training

Aircraft Environmental Systems Mechanic

USAF GRADUATE EVALUATION PROGRAM

18 April 1983

CHANUTE TECHNICAL TRAINING CENTER (ATC)
3370 Technical Training Group
Chanute Air Force Base, Illinois

DESIGNED FOR ATC COURSE USE.

DO NOT USE ON THE JOB.

RGL: 9.5

OBJECTIVE

Identify facts relating to the USAF Graduate Evaluation Program. A minimum of 4 out of 5 must be correct.

INSTRUCTIONS

Read each frame carefully. You will have a five question test to answer when you have finished reading this programmed text.

INTRODUCTION

As a student in a formal training course, it is easy to think that the school you are in has not changed since it began. That is far from being true! All Air Force formal training courses change as a result of (1) changes in equipment, procedures, or needs of the Air Force; (2) occupational surveys and (3) the Graduate Evaluation Program.

This programmed text will explain the USAF Graduate Evaluation program. This program sets up a system for evaluating graduates of formal courses (such as this one) and graduates of Career Development Courses (CDCs).

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3370 TCHTG/TTGU-P - 500; DAV - 1

USAF GRADUATE EVALUATION PROGRAM

Introduction

AFR 50-38 sets up a way to evaluate graduates of formal courses (such as the one you are in now), graduates of career development courses (CDC) and computer directed training system (CDTS) courses.

Frame 1

Field evaluations are the main source of information used in the quality control of formal resident courses, non-resident courses and CDCs.

Through this information, we are able to judge the

a. ability of recent graduates to do their assigned job tasks at the level of proficiency shown in the applicable training standard.

b. extent to which learned skills are used by recent graduates.

c. extent to which graduates keep the knowledge and skills they have learned.

d. need to change training standards, formal courses and CDC courses to improve training.

e. need for further evaluation of the education and training problem areas identified by field evaluations.

Frame 2

Those activities that operate formal courses, as shown in AFM 50-5 USAF Formal Schools Catalog, and/or prepare CDCs will look at and use the facts they get through field evaluations. These facts determine how good their course is and aid in making changes when and where there is a need for a change.

Frame 3

There are four ways to do field evaluations. Any and all of these ways may be used. The four ways are:

1. Field Evaluation Visits
2. Direct Correspondence Questionnaires
3. Evaluation of CDCs
4. Job Performance Evaluations

We will now look at each of these four ways.

Frame 4

Field Evaluations Visits are done by the training activities. The personnel from the training activities will go out to the field to do these evaluations. They are concerned with people who have graduated in four to six months prior to their visit. Evaluation data is obtained through talks with the graduate, the immediate supervisor and others that know how well the graduate can do the job. The applicable training standard is used as the reference to judge how often and how well the graduate does the tasks for which he or she was trained.

Frame 5

Direct correspondence questionnaires are the most commonly used means of field evaluation. The questions that are asked in this survey have to do with the graduates qualifications in terms of the skills and proficiency levels shown in the training standard. These questionnaires are

a. sent to recent graduates and their supervisors.

b. mailed by the training activities to units that receive graduates 3-6 months after graduation.

Frame 6

When there are enough responses to the questionnaire, a Training Evaluation Report is made by the Evaluation Division of the technical training center concerned. This report is an in-depth study of the information received from the supervisors for suggested improvements. All of this information is used by the evaluators to help them make valid reports. The results of their reports are immediately responded to by course personnel, resulting in the change(s) necessary to adapt that training to the total AF needs.

Unfortunately, it is not cost effective to train all students to do all job tasks they will meet in all job assignments. School training time must be slanted toward satisfying the common needs, Air Force wide. Those additional job performance needs, that are peculiar to an individual's job assignment, must be acquired through on-the-job training (OJT).

Frame 7

The third method is Evaluation of CDCs. The Extension Course Institute (ECI) will include specific questions in the last CDC volume review exercise booklet to ask student opinion about the effectiveness of the CDC.

ECI will gather evaluation data from the replies to the questionnaires, summarize the data, and provide this information to the training activity responsible for preparing the CDC. If the evaluation data indicates problems with the CDC content, the responsible training activity will conduct a followup evaluation to determine corrective actions. AF Form 1284 (explained later in this PT) will be used to report CDC deficiencies.

Frame 8

Job Performance Evaluations may be conducted if the required training evaluation cannot be obtained by less costly methods. Job Performance Evaluations are exactly that. The training agency will evaluate actual job performance by graduates to see if the graduates meet or exceed applicable training standards.

Frame 9

There is one main form used in the USAF Graduate Evaluation Program. This form is an AF Form 1284, Training Quality Report. (See figure 1.) The AF Form 1284 is used to give feedback to ATC and other commands and organizations that conduct education and training courses. It is used to document the quality of recruit training, specialized skill training (including resident courses), field training detachment courses, mobile training team courses and CDCs. The form is also used to give feedback on graduates from non-ATC schools which conduct specialized skill training.

Instructions for preparing AF Form 1284 are on the back of the form (See figure 2.)

This form is for use by supervisors throughout all commands. The immediate supervisor must prepare this report if

1. course graduates are undertrained. (Do not meet specified level for training.)
2. course graduates are overtrained. (Exceed level specified for training.)
3. CDC content does not support specified level of training.
4. within six (6) months of Basic Training, the graduate demonstrates severe deficiencies in standards of conduct or discipline.
5. CDC deficiencies are noted.

See your instructor testing at this time.

TRAINING QUALITY REPORT (TQR)

(See Instructions on Reverse)

1. FROM: *(Using Activity Address)*
60th CG/CCQT
Travis AFB, CA 94535

2. TO: *(Copy 1)*
HQ ATC/
RANDOLPH AFB, TX 78148

3. TO: *(Copy 2) (MAJCOM/DPAT Address)*
HQ AFCC/MPXT
Randolph AFB, TX

4. NAME OF GRADUATE *(Last, First, Middle Initial)*: Doe, John L.

5. SSAN: 123-45-6789

6. GRADE: AMN

7. UNIT OF ASSIGNMENT: 60th FMS/MMB

8. BASE: Travis AFB, CA

COURSE *(Not required for BMT)*

9. NUMBER: C3ABR42331

10. TITLE: Aircraft Environmental Systems Mechanic

11. GRADUATION DATE: June 82

SPECIALTY OR COURSE TRAINING STANDARD *(STS/CTS)*

12. NUMBER: 423X1

13. TITLE: Aircraft Environmental Systems Mechanic

14. DATE: Jan 82

Provide the required information below when the graduate cannot meet the specialty/course training standard proficiency levels specified for the course. In Block 14 identify the appropriate job areas, i.e. Aircraft General, Elec System, Medical Techniques, etc. In Block 15, match the job areas with specific task and/or knowledge items in the STS/CTS. In Block 16 "Remarks" explain the inadequacy in identifying the specific equipment or procedures involved. Use examples if possible.

15. JOB AREA A	16. STS REFERENCE ITEM NO. B	PROFICIENCY CODE C	17. REMARKS D
Cryotainer Maintenance	24a	B	Amn Doe was unfamiliar with the operation of the liquid oxygen cryotainer; required extensive OJT to meet the "B" standard.
Liquid Refrigeration Systems And Components	23c	2b	Individual could not operate the basic refrigeration system on the comfort pallet; totally unfamiliar with procedures. Amn Doe stated he did not remember covering the subject matter during tech school.
Life Raft Inflation Equipment	22f(2)	2b	Individual was totally unfamiliar with the safety precautions relative to servicing inflation cylinders; Amn Doe stated he did not remember covering the subject matter during tech school.

18. DATE: 3 July 82

19. GRADE, NAME AND SIGNATURE OF SUPERVISOR: SSgt John A. Smith

20. AUTOVON NO.: 37690102

AF FORM FEB 81 1284 PREVIOUS EDITON IS OBSOLETE.

Figure 1.

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Figure 2.

INSTRUCTIONS

1. General.

a. Use this form to provide feedback on the quality of:

(1)	Specialized Skill Training	(4)	Career Development Courses (CDCs)
(2)	Field Training	(5)	Recruit Training (BMT)
(3)	Phase II Medical Training	(6)	Computer Directed Training System (CDTS) Courses

b. Do not use this form to recommend a change to the current STS/CTS. Process training standard changes through command channels (See AFR 8-13).

c. This form is optional for ATC undergraduate flying training, survival courses, flying training programs, and professional development education courses.

d. Prepare this form when:

(1) Course graduates are undertrained. (Graduates do not meet the level specified for training in the current Specialty or Course Training Standard (STS/CTS) or flying syllabi.)

(2) Course graduates are overtrained. (Graduates exceed the level specified for training in the current STS/CTS/flying syllabi or are trained for tasks they are not required to perform.)

(3) Within 6 months of completing Recruit Training, graduate demonstrates severe deficiencies in standards of conduct or discipline.

(4) CDC content does not support subject/task knowledge levels in STS.

2. Specific instructions related to numbered blocks on front side of form.

a. Block 1. Self-explanatory.

b. Block 2. For ATC technical training courses send to HQ ATC/TTSE. For ATC undergraduate flying training courses and survival courses send to HQ ATC/DOVA. For non-ATC courses, substitute the address of the school which conducted the training.

c. Blocks 3-5. Self-explanatory.

d. Blocks 7-8. Identify student's unit and base of assignment.

e. Blocks 9-11. Identify number and title of course student attended in addition to graduation date.

f. Blocks 12-14. Identify the number, title and date of the training standard/course control document you are using.

g. Block 15. Identify job areas in which graduate is having difficulty; for example: contingency responsibilities, air traffic control publications, cable splicing, common automatic test equipment, etc.

h. Block 16. Relate job area to specific tasks or knowledge on current STS/CTS or other course control document. Identify specific training standard item. Also, include proficiency code for the flying syllabi/STS/CTS items you cite.

i. Block 17. Briefly explain deficiency.

(1) Review those specific STS/CTS/flying syllabi tasks, proficiency codes, and the proficiency code key on page 2 of all training standards. (To what level did the training organization agree to train on this task?)

(2) Compare graduate's ability to perform the task to the proficiency code representing the level to which the training organization agreed to train. (Did the training organization notify you of a training deficiency related to the task in question?)

(3) Consult with other supervisors of course graduates, if possible, to make sure that your expectations of the graduate's performance is as objective as possible. Be sure you are evaluating the graduate's job performance and not the graduate.

(4) If you need assistance, ask a representative from the OJT Advisory Service, your unit OJT monitor, or available field training detachment personnel for help.

j. Block 18. Identify the form preparation date.

k. Blocks 19-20. Identify supervisor and supervisor's autovon number so that anyone using or getting information copies of the form can call for additional information.

NOTE. Direct questions and recommendations pertaining to this form and its use to HQ USAF/MPPTS, WASHINGTON DC 20330 Autovon 225-7321.

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